BURNY KALIBURN
A Lincoln Electric Company

User's Manual

Spirit II 150

High Current Density Plasma Cutting System with Manual Gas Console (MGC)

BK718114 Rev F

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Revision History

Rev	ECO#	Author	Date	Description of Change
A	-	CAD	02/04/2013	Initial Release
B	LAD0202	CAD	06/07/2013	Added 100A/150A silver electrodes, replaced RHF with ISC, corrected system interconnect diagrams, changed rated inlet gas pressure to 115 psi, added 100 psi minimum to inlet gas pressure.
C	LAD0217	CAD	08/06/2013	Deionization filter cartridge (500510) replaced sediment filter (300152). Parts list updated. Expanded notes on System Interconnection diagrams to clarify cabling requirements for various configurations.
D	LAD0228 LAD0223	CAD	08/28/2013	Corrected contact ratings on page 3-19. Added pinouts to CII, FII, JII cables in Parts List. Corrected part numbers for coolant/power leads and work ground in Parts List.
E	LADC0260	CAD	03/18/2014	Inductor (707150) replaced by (707155). 10" fan (500516) replaced by (284031). Added notes about torch handle vent hole. Updated Chopper Test Procedure.
F	LAD0264	CAD	03/31/2014	Added "BK" prefix to all part numbers. Added PCB Outline Dwgs and corrected electrode tool in Part List. Corrected Remote On/Off info in Installation section.

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Limited Warranty

KALIBURN expressly warrants that this product shall be free from defects in materials and workmanship, under proper and normal use for the intended function of such product, for a period of three (3) years for the Spirit II plasma power supply (includes the cooling system and internally installed Inova option) and one (1) year for all other Spirit II system component. This warranty does not apply to torch consumable parts.

The warranty period starts three (3) months after the product ships from the factory.

This product is intended for commercial use and is not intended for personal, family, or household purposes. There are no warranties that extend beyond the express limited warranty set forth immediately above. All other warranties, whether expressed, implied, statutory or made herein or in any other communication, including any implied warranty of merchantability, fitness for any particular purpose or non-infringement, are expressly excluded.

This warranty will be considered void if the Spirit II system is operated with non-genuine KALIBURN torch consumables, or if the equipment has been subjected to improper installation, improper care or abnormal operation.

If this product or any component thereof is determined to be defective in materials or workmanship, KALIBURN will repair or replace the defective component or product. The buyer's remedies are limited to the return of the product for repair or replacement of any defective product or part at the sole discretion of KALIBURN. No freight charges of any kind are covered under this warranty. All returned goods shall be at the buyer's risk and expense. In no event will KALIBURN be responsible for any special, incidental or consequential damages or injury to the person or property of anyone by reason of any defect in any equipment sold hereunder.

Returned Goods Procedure

KALIBURN utilizes a returned goods procedure that must be followed before returning any items for repair, replacement, or restocking. This means that a returned goods authorization number must be obtained prior to shipment to KALIBURN. It will be necessary for the customer to provide a description, along with the part number and serial number, if applicable, of the item to be returned. In no case will KALIBURN accept a returned shipment without the proper returned goods authorization number.

For shipments inside the U.S., parts must be returned to KALIBURN within 30 days of the invoice date to be considered for credit. For shipments outside the U.S., parts must be returned within 60 days of the invoice date to be considered for credit.

Electromagnetic Compatibility (EMC)

The 380V 50/60Hz and 415V 50/60Hz CE marked Spirit II plasma cutting systems are manufactured to comply with the European standard EN 60974-10 (Electromagnetic compatibility (EMC) – Product standard for arc welding equipment). Information about the EMC standard EN 60974-10 can be found in Appendix A.

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Section 1: Safety

General Precautions

Whereas plasma cutting has been used safely for years, it does require certain precautions to ensure the safety of the operator and other people around the equipment. The following safety information must be provided to each person who will operate, observe, perform maintenance, or work in close proximity to this piece of equipment.

Installation, operation, and repairs made to the Spirit system should only be performed by qualified personnel. The system makes use of both A.C. and D.C. circuitry for operation. **Fatal shock hazard does exist. Exercise extreme caution while working on the system**.

Ultraviolet Radiation Protection

Plasma cutting produces ultraviolet radiation similar to a welding arc. This ultraviolet radiation can cause skin and eye burns. For this reason, it is essential that proper protection be worn. The eyes are best protected by using safety glasses or a welding helmet with an AWS No. 12 shade or ISO 4850 No. 13 shade, which provides protection up to 400 amperes. All exposed skin areas should be covered with flame-retardant clothing. The cutting area should also be prepared in such a way that ultraviolet light does not reflect. Walls and other surfaces should be painted with dark colors to reduce reflected light. Protective screens or curtains should be installed to protect additional workers in the area from ultraviolet radiation.

Noise Protection

The system generates high noise levels while cutting. Depending on the size of the cutting area, distance from the cutting torch, and arc current cutting level, acceptable noise levels may be exceeded. Proper ear protection should be used as defined by local or national codes. See Section 2 for noise emission levels.

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Toxic Fume Prevention

Care should be taken to ensure adequate ventilation in the cutting area. Some materials give off toxic fumes that can be harmful or fatal to people in the vicinity of the cutting area. Also, some solvents decompose and form harmful gases when exposed to ultraviolet radiation. These solvents should be removed from the area prior to cutting. Galvanized metal can produce harmful gases during the cutting process. Ensure proper ventilation and use breathing equipment when cutting these materials.

Certain metals coated with or containing lead, cadmium, zinc, beryllium, and mercury produce harmful toxins. Do not cut these metals unless all people subjected to the fumes wear proper air breathing equipment.

Electric Shock Prevention

The Spirit system uses high open circuit voltages that can be fatal. Extreme care should be used when operating or performing maintenance on the system. Only qualified personnel should service the system. Observe the following guidelines to protect against electric shock:

- A wall-mounted disconnect switch should be installed and fused according to local and national electrical codes. The disconnect switch should be located as close as possible to the power supply so it can be turned off in case of an emergency.
- The primary power cord should have a 600 volt minimum rating in order to protect the operator. In addition, it should be sized according to local and national electrical codes. Inspect the primary power cord frequently. Never operate the system if the power cord is damaged in any way.
- Make sure the primary power ground wire is connected to the input power ground stud on the power supply. Make sure the connection is securely tightened.
- Make sure the positive output (work ground) of the power supply is connected to a bare metal area on the cutting table. A driven ground rod should be placed no further than five feet from this connection. Make sure this ground point on the cutting table is used as the star ground point for all other ground connections.
- Inspect the torch leads frequently. Never use the system if the leads are damaged in any way.
- Do not stand in wet, damp areas when operating or performing maintenance on the system.
- Wear insulated gloves and shoes while operating or performing maintenance on the system.
- Make sure the system is switched off at the wall disconnect before servicing the power supply or torch.

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- Never change torch consumable parts unless the system is switched off at the wall disconnect.
- Do not attempt to remove any parts from beneath the torch when cutting. Remember that the workpiece forms the current path back to the power supply.
- Never bypass the safety interlock devices.
- Before removing any of the covers, switch the system off at the wall disconnect. Wait at least five (5) minutes before removing any cover. This will give the capacitors inside the unit time to discharge. See Section 6 for additional safety precautions.
- Never operate the system without all of the covers in place. See Section 6 for additional safety precautions.
- Preventive maintenance should be performed daily to avoid possible safety hazards.

Fire Prevention

When using the Spirit system, it is necessary to exercise good judgment. While cutting, the arc produces sparks that could cause a fire if they fall on flammable materials. Make sure that all flammable materials are a suitable distance away from the cutting area. All flammable liquids should be at least 40 feet away from the cutting area, preferably stored in a metal cabinet. Plasma cutting should never be attempted on containers that contain flammable materials. Make sure that fire extinguishers are readily accessible in the cutting area.

Make sure that the cutting area is properly ventilated when using oxygen as a cutting gas.

Explosion Prevention

The Spirit system uses compressed gases. Use proper techniques when handling compressed gas cylinders and other compressed gas equipment. Observe the following guidelines to protect against explosion:

- Never operate the system in the presence of explosive gases or other explosive materials.
- Never cut pressurized cylinders or any closed container.
- When using a water table and cutting aluminum under water or with water touching the underside of the aluminum plate, hydrogen gas is produced. This hydrogen gas may collect under the plate and explode during the cutting process. Make sure the water table is properly aerated to help prevent the accumulation of hydrogen gas.
- Handle all gas cylinders in accordance with safety standards published by the U.S. Compressed Gas Association (CGA), American Welding Society (AWS), Canadian Standards Association (CSA), or other local or national codes.

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- Compressed gas cylinders should be maintained properly. Never attempt to use a cylinder that is leaking, cracked, or has other signs of physical damage.
- All gas cylinders should be secured to a wall or rack to prevent accidental knock over.
- If a compressed gas cylinder is not being used, replace the protective valve cover.
- Never attempt to repair compressed gas cylinders.
- Keep compressed gas cylinders away from intense heat, sparks, or flames.
- Clear the compressed gas cylinder connection point by opening the valve momentarily prior to installing a regulator.
- Never lubricate compressed gas cylinder valves or pressure regulators with any type of oil or grease.
- Never use a compressed gas cylinder or pressure regulator for any purpose other than which it is intended.
- Never use a pressure regulator for any gas other than which it is intended.
- Never use a pressure regulator that is leaking or has other signs of physical damage.
- Never use oxygen hoses and pressure regulators for any gas other than oxygen.
- Never use any gas hose that is leaking or has other signs of physical damage.

Health Support Equipment

The Spirit system creates electric and magnetic fields that may interfere with certain types of health support equipment, such as pacemakers. Any person who uses a pacemaker or similar item should consult a doctor before operating, observing, maintaining, or servicing the system. Observe the following guidelines to minimize exposure to these electric and magnetic fields:

- Stay as far away from the power supply, torch, torch leads, and impulse start console as possible.
- Route the torch leads as close as possible to the work ground cable.
- Never place your body between the torch leads and work ground cable. Keep the work ground cable and the torch leads on the same side of your body.
- Never stand in the center of a coiled up set of torch leads or work ground cable.

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Safety Standards Booklet Index

For further information concerning safety practices to be exercised with plasma arc cutting equipment, please refer to the following publications:

1. AWS Standard AWN, *Arc Welding and Cutting Noise*, obtainable from the American Welding Society, 550 NW LeJeune Road, Miami, FL 33126.

2. AWS Standard C5.2, *Recommended Practices for Plasma Arc Cutting*, obtainable from the American Welding Society, 550 NW LeJeune Road, Miami, FL 33126.

3. AWS Standard FSW, *Fire Safety in Welding and Cutting*, obtainable from the American Welding Society, 550 NW LeJeune Road, Miami, FL 33126.

4. AWS Standard F4.1, Recommended *Safe Practices for Preparation for Welding and Cutting of Containers and Piping*, obtainable from the American Welding Society, 550 NW LeJeune Road, Miami, FL 33126.

5. AWS Standard ULR, *Ultraviolet Reflectance of Paint*, obtainable from the American Welding Society, 550 NW LeJeune Road, Miami, FL 33126.

6. AWS / ANSI Standard Z49.1, *Safety in Welding, Cutting, and Allied Processes,* obtainable from the American Welding Society, 550 NW LeJeune Road, Miami, FL 33126.

7. ANSI Standard Z41.1, *Standard For Men's Safety-Toe Footwear*, obtainable from the American National Standards Institute, 11 West 42nd Street, New York, NY 10036.

8. ANSI Standard Z49.2, *Fire Prevention in the Use of Cutting and Welding Processes*, obtainable from the American National Standards Institute, 11 West 42nd Street, New York, NY 10036.

9. ANSI Standard Z87.1, *Safe Practices For Occupation and Educational Eye and Face Protection,* obtainable from the American National Standards Institute, 11 West 42nd Street, New York, NY 10036.

10. ANSI Standard Z88.2, *Respiratory Protection*, obtainable from the American National Standards Institute, 11 West 42nd Street, New York, NY 10036.

11. OSHA Standard 29CFR 1910.252, *Safety and Health Standards,* obtainable from the U.S. Government Printing Office, Washington, D.C. 20402.

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12. NFPA Standard 51, *Oxygen - Fuel Gas Systems for Welding, Cutting, and Allied Processes*, obtainable from the National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269.

13. NFPA Standard 51B, *Cutting and Welding Processes*, obtainable from the National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269.

14. NFPA Standard 70, *National Electrical Code*, obtainable from the National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269.

15. CGA booklet P-1, *Safe Handling of Compressed Gases in Containers*, obtainable from the Compressed Gas Association, 1725 Jefferson Davis Highway, Suite 1004, Arlington, VA 22202.

16. CGA booklet P-14, *Accident Prevention in Oxygen-Rich and Oxygen-Deficient Atmospheres*, obtainable from the Compressed Gas Association, 1725 Jefferson Davis Highway, Suite 1004, Arlington, VA 22202.

17. CGA booklet TB-3, *Hose Line Flashback Arrestors*, obtainable from the Compressed Gas Association, 1725 Jefferson Davis Highway, Suite 1004, Arlington, VA 22202.

18. CSA Standard W117.2, *Safety in Welding, Cutting, and Allied Processes*, obtainable from Canadian Standards Association, 178 Rexdale Boulevard, Toronto, Ontario M9W lR3, Canada.

19. Canadian Electrical Code Part 1, *Safety Standard for Electrical Installations,* obtainable from the Canadian Standards Association, 178 Rexdale Boulevard, Toronto, Ontario M9W 1R3, Canada.

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Section 2: Specifications

System Description

The Spirit II 150 is a 150 amp microprocessor controlled, 100% duty cycle high current density plasma cutting and marking system. It utilizes a precision, dual gas torch that is capable of cutting mild steel up to 1-1/2" thick and stainless steel up to 1" thick.

The system contains a manually controlled gas console, which also provides the primary interface to the entire Spirit system.

For cutting mild steel, the system uses oxygen for the plasma gas and either oxygen or air for the shielding gas. When cutting stainless steel or other non-ferrous materials, air or H17 (17.5% hydrogen, 32.5% argon, 50% nitrogen) is used for the plasma gas and either air or nitrogen is used for the shielding gas. Oxygen and nitrogen are used for the preflow and postflow gases.

The torch is water-cooled and consumables are machined to exacting dimensions and checked with the latest computerized measuring systems. Five nozzle sizes (30, 50, 70, 100, and 150 amps) are available to produce excellent cut quality throughout the cutting range.

Each enclosure in the system is rated for IP21S sealing, which is intended for indoor use only. The system is not suitable for use in rain or snow.

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System Components

The Spirit II 150 System consists of the following components:

Standard Components

- Power Supply
- Manual Gas Console
- CAN Cable
- CAN Termination Plug
- Impulse Start Console (ISC)
- ISC Control Cable
- ISC Ground Cable
- Torch and Handle Assembly
- Torch Lead Set
- 5-gang Manifold Assembly
- 5-gang Manifold Control Cable
- 2-gang Manifold Assembly
- 2-gang Manifold Control Cable
- 17 Inch Plasma Hose
- Coolant and Power Leads
- Gas Hose Package
- Work Ground Lead
- Spirit II User's Manual

Optional Components

- Supply Gas Hoses
- Internal Inova Console

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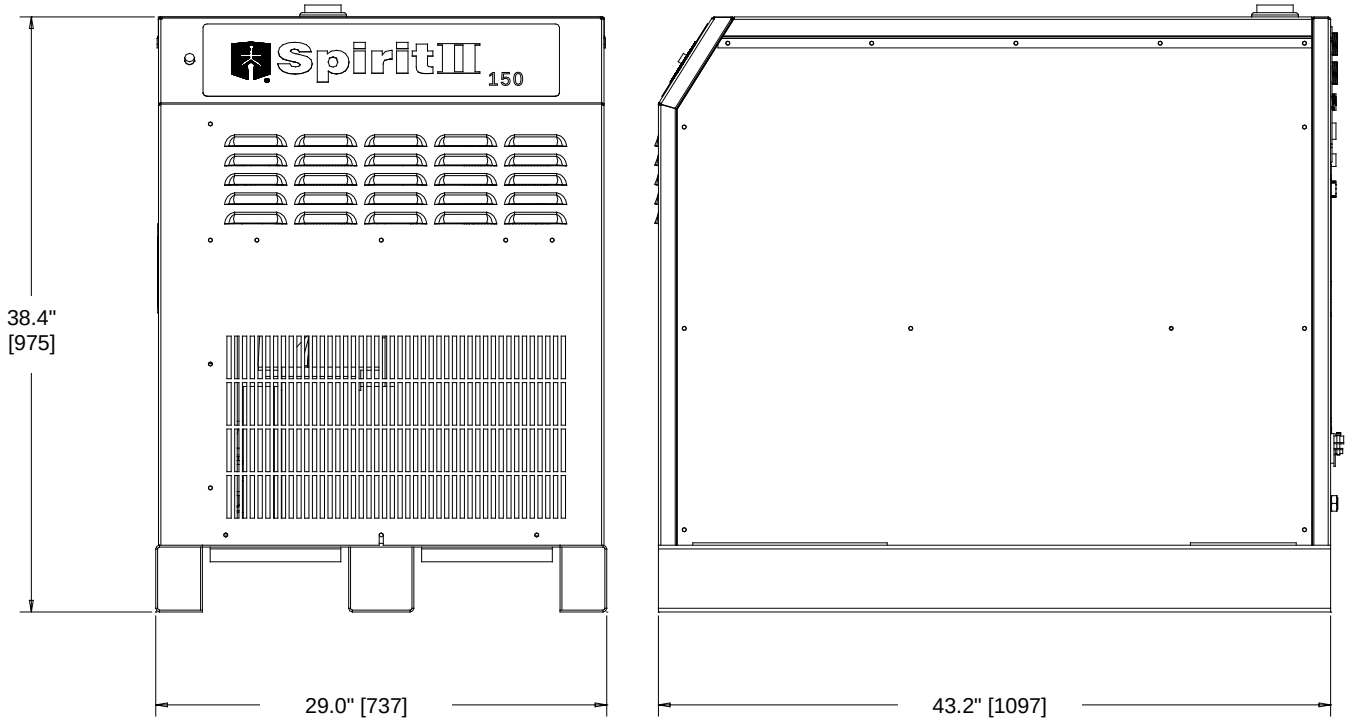
Power Supply Specifications

Power Supply Description	Part Number	Input Current at Maximum Output
208 VAC, 3Ø, 60Hz	BK300211	99 amps
220 VAC, 3Ø, 60Hz	BK300212	94 amps
240 VAC, 3Ø, 60Hz	BK300213	86 amps
380 VAC, 3Ø, 50/60Hz	BK300214	54 amps
400 VAC, 3Ø, 50/60Hz	BK300215	52 amps
415 VAC, 3Ø, 50/60Hz	BK300216	50 amps
440 VAC, 3Ø, 50/60Hz	BK300217	47 amps
480 VAC, 3Ø, 60Hz	BK300218	43 amps
600 VAC, 3Ø, 60Hz	BK300219	34 amps

Open Circuit Voltage..... 300 VDC
Output Current (drooping characteristic)..... 10 - 150 amps
Maximum Output Voltage ..... 170 VDC
Duty Cycle ..... 100% @ 25.5 kW
Maximum Ambient Temperature..... 104° F (40° C)
Coolant Discharge Pressure ..... 150 psi (10.2 bar)
Coolant Flow Rate ..... 1 gal/min (3.8 liters/min)
Coolant Fluid..... Propylene glycol solution
Coolant Tank Capacity..... 3.2 gal (12 liters)
Weight (without coolant) ..... 953 lb (432 kg)



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Torch Coolant Specifications

Note: Refer to the supplier's most current Material Safety Data Sheet for information regarding safety, handling, and storage of torch coolant.

The Spirit system is shipped without torch coolant in the reservoir. **Coolant must be added before applying power to the system.** Only use Kaliburn approved torch coolant solution for optimal system performance as commercially available antifreeze contains corrosion inhibitors that will damage the cooling system. The standard coolant solution consists of 25% industrial grade propylene glycol and provides freezing protection down to -13º C (9º F). The standard solution can be ordered in one-gallon containers, PN BK500695. For operating temperatures below -13º C, a 50% solution of industrial grade propylene glycol can be ordered in one-gallon containers, PN BK500895, providing protection down to -36º C (-33º F).

Failure to use the proper propylene glycol solution may result in cooling system and/or torch damage.

The torch coolant should be flushed out of the Spirit system every six months and replaced with new coolant. The coolant filter / deionization cartridge should also be changed at the same time. See Section 6 for details.

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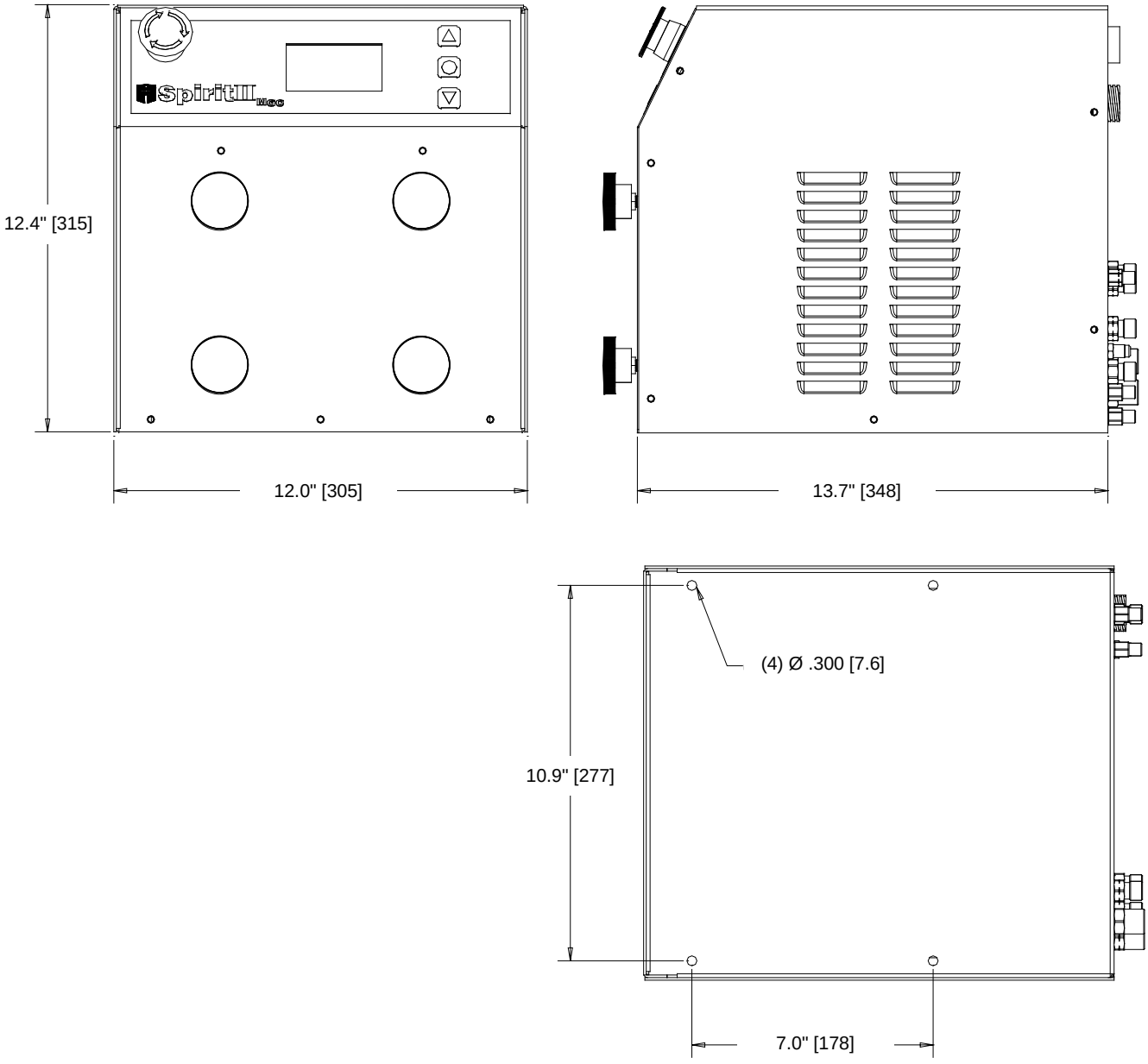
Manual Gas Console (MGC) Specifications

Part Number BK300600
Weight ..... 50 lb (23 kg)



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Gas Supply Requirements

Plasma gas types:
- Mild Steel..... Oxygen
- Stainless Steel ..... Air or H17
- Aluminum ..... Air

Shield gas types:
- Mild Steel..... Oxygen or Air
- Stainless Steel..... Air or Nitrogen
- Aluminum ..... Nitrogen

Preflow gas type ..... Oxygen and Nitrogen
Marking gas type..... Nitrogen

Plasma gas flow rate (maximum):
- Oxygen or Air..... 67 scfh (1897 liters/hour)
- H17..... 75 scfh (2124 liters/hour)

Shield gas flow rate (maximum):
- Oxygen ..... 19 scfh (538 liters/hour)
- Air or Nitrogen ..... 225 scfh (6371 liters/hour)

Preflow gas flow rate (maximum)..... 60 scfh (1699 liters/hour)
Marking gas flow rate (maximum)..... 67 scfh (1897 liters/hour)

Rated Inlet gas pressure..... 115 psi (7.9 bar)
Minimum Inlet gas pressure..... 110 psi (7.6 bar)
Maximum Inlet gas pressure..... 145 psi (10.0 bar)

Oxygen and nitrogen should be supplied with a purity of at least 99.5%.
H17 should be supplied with a purity of at least 99.995%.

A potential fire hazard exists when cutting with oxygen. KALIBURN recommends that an exhaust ventilation system be used when cutting with oxygen. Flashback arrestors must be supplied (unless they are not available for the chosen gases and pressures) to prevent a possible fire from propagating back to the gas supplies.

Ensure that oxygen lines remain free from contaminants such as oil and grease. The mixture of such contaminants with oxygen presents an additional fire hazard.

Compressed air must be clean, dry, and oil-free and may be supplied from compressed cylinders or from an air compressor. Be aware that shop air systems are prone to oil and moisture contamination. If shop air is used, it must be cleaned to ISO 8573.1: Class 1.4.1. Specify dry air when using compressed cylinders. Breathing quality air contains moisture and must not be used.

3/8" (inside diameter) hoses are required for all inlet gas connections. Mating connectors are supplied with the unit. **Quick-connect fittings must not be used.**

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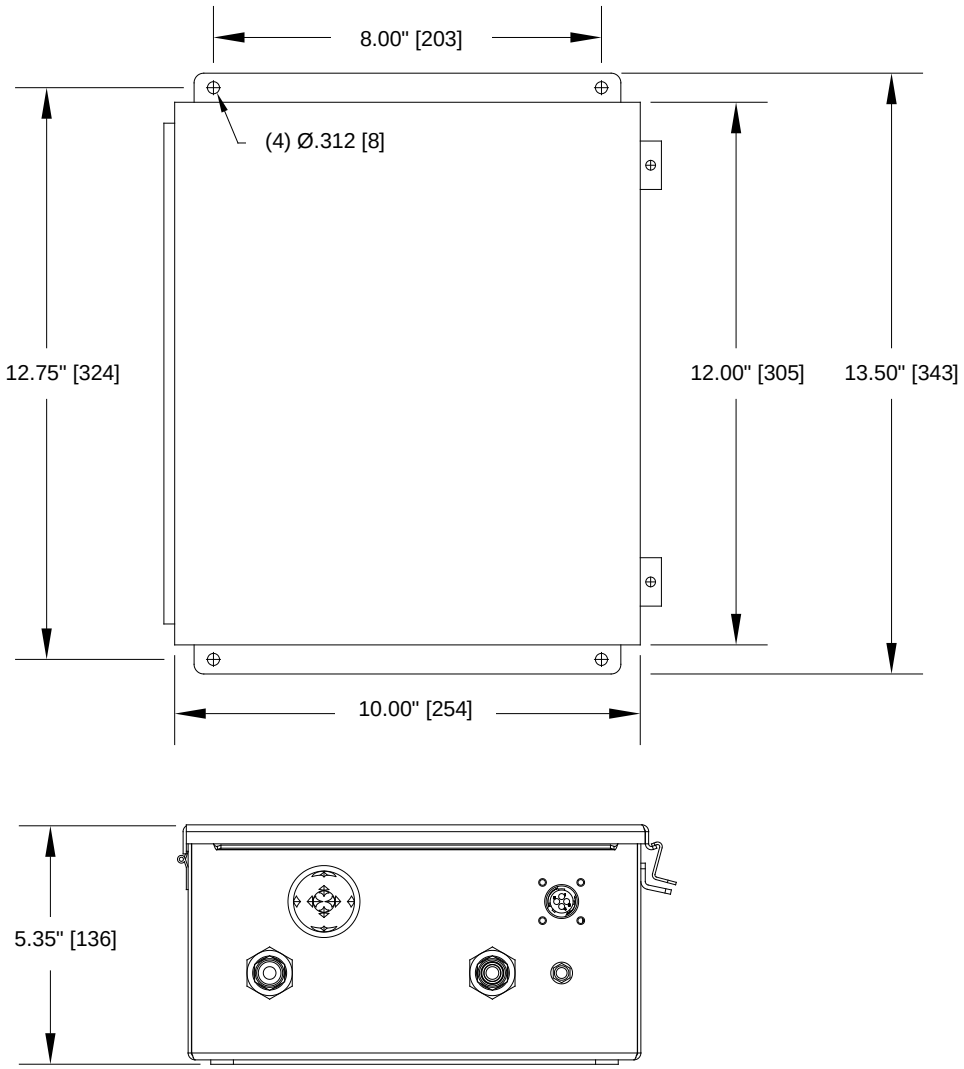
Impulse Start Console (ISC) Specifications

Part Number BK300500
Weight ..... 22 lb (10 kg)



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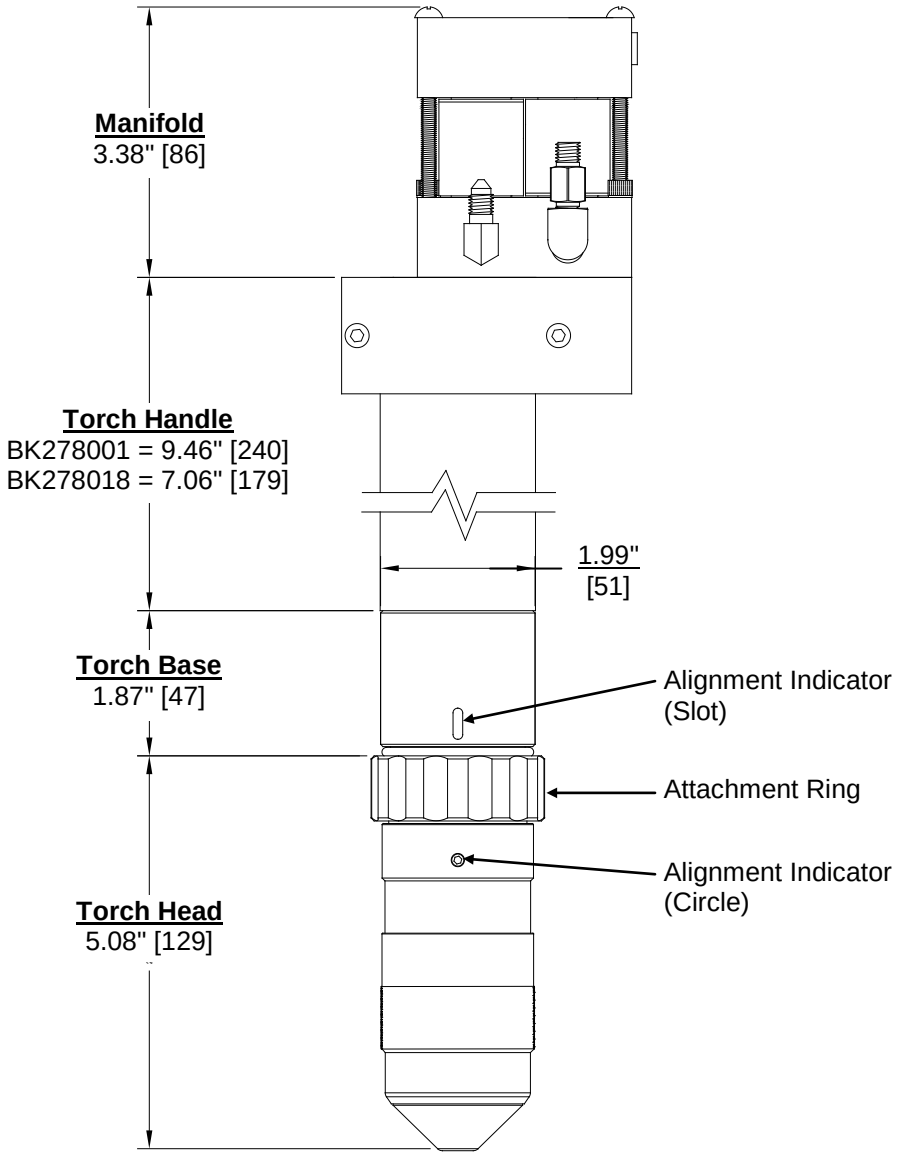
Torch and 2-Gang Manifold Specifications

Part Number:

2-Gang Manifold Assembly	BK284214
Torch Handle (standard)	BK278001
Torch Handle (short)	BK278018
Torch Base	BK279000
Torch Head (Copper Electrode)	BK279100
Torch Head (Silver Electrode)	BK279060

Max Weight:

Manifold/Bracket, Handle (BK278001), Base and Head ..... 8.3 lbs (3.8 kg)



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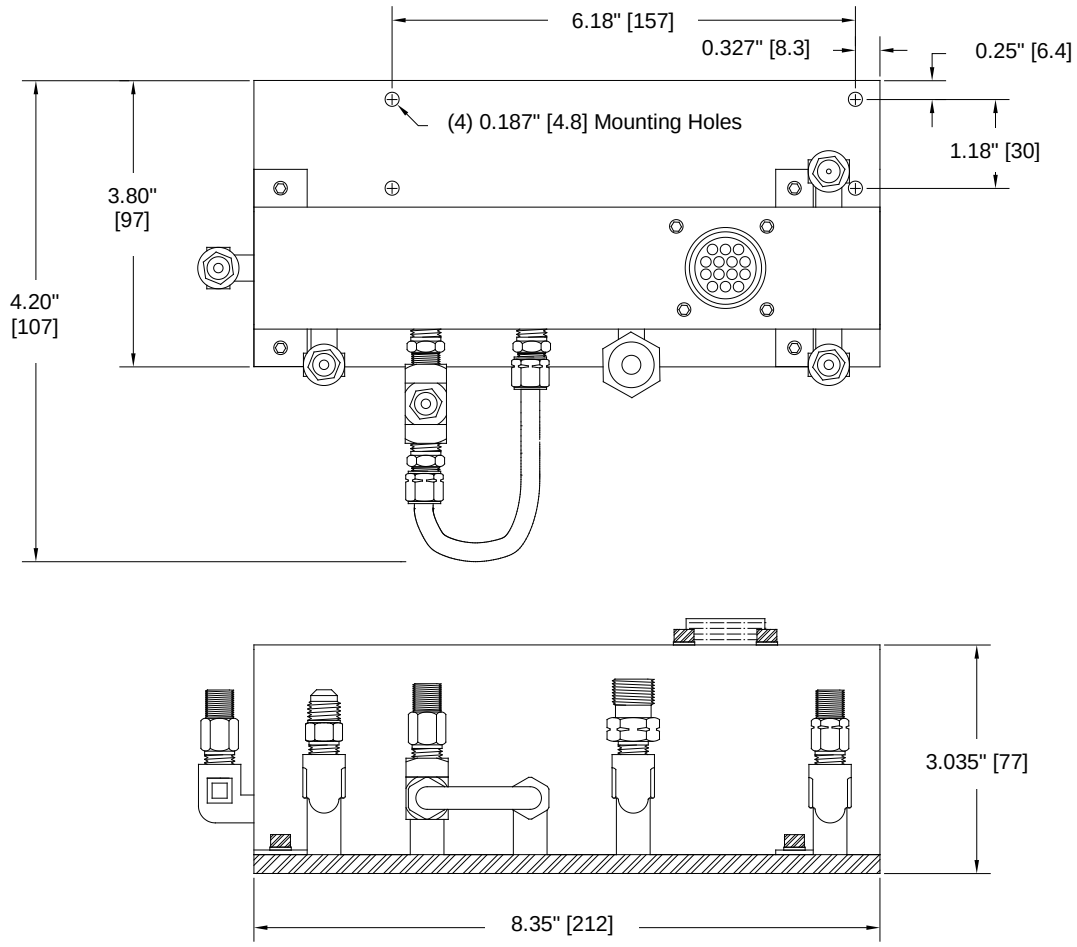
5-Gang Manifold Specifications

Part Number BK280022
Weight ..... 6 lb (2.7 kg)



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Airborne Noise Emissions

The system generates high noise levels while cutting. Depending on the size of the cutting area, distance from the cutting torch, and arc current cutting level, acceptable noise levels may be exceeded. Proper ear protection should be used as defined by local or national codes. The following chart gives the noise levels generated by the system when operating at 150 amps, 130 arc volts. The measurements were made with a sound level meter.

Distance From Torch	A-Weighted Sound Pressure Level	C-Weighted Sound Pressure Level
1 meter horizontal / 1.6 meters above the workpiece	97 dB	94 dB

The maximum noise level is 121 dB at a distance of 3 inches (76.2 mm) from the torch while cutting at 150 amps, 130 arc volts.

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Section 3: Installation

Initial Inspection

All systems undergo full testing before being shipped from Kaliburn. In the unlikely event that one of the components is defective or missing, please contact Kaliburn so a replacement item can be sent. Also, Kaliburn has taken special care in packaging the system. If the system was damaged during shipment, file a claim with the shipping company, and then contact Kaliburn to order replacement parts.

Component Placement

Plasma Power Supply

The power supply should be lifted by a forklift or pallet jack. In order to prevent damaging the power supply, the forks should be of adequate length to protrude on the far side of the power supply. The proper location of the power supply will provide dependable service and reduce periodic maintenance time. Choose a location that will provide unrestricted air movement into and out of the power supply. Maintain **at least 24 inches** of space on **all** sides of the unit. The location should subject the power supply to the least amount of dust, dirt, moisture, and corrosive vapors. The surface on which the power supply is located should have a grade of no greater than 10º to eliminate the risk of toppling over. The power supply must be cleaned as often as necessary to prevent the accumulation of metallic dust inside the unit. See Section 2 for unit dimensions.

Manual Gas Console (MGC)

The MGC should be mounted near the CNC controller so that it is easy accessible by the operator. See Section 2 for mounting dimensions.

Impulse Start Console (ISC)

The ISC should be mounted in a convenient location that is away from other electronic control devices. The ISC offers significantly reduced emissions compared to traditional high frequency, however, the high voltage pulse generated inside the unit may interfere with the operation of sensitive control electronics. The ISC is usually mounted on the gantry of the cutting machine or on the cutting table. See Section 2 for mounting dimensions.

5-Gang Manifold

The 5-gang manifold assembly must be mounted within 6 feet (1.8 m) of the torch. See Section 2 for mounting dimensions.

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2-Gang Manifold
The 2-gang manifold assembly must be mounted to the torch. See Section 2 for mounting dimensions.

Torch
The torch must be installed on the positioner of an arc voltage control (height control) capable of maintaining the cutting arc voltage within 1 arc volt. The arc voltage must be adjustable in 1 arc volt increments. The positioner must be rigid to ensure cut quality and a torch collision sensor is highly recommended. See Section 2 for mounting dimensions.

System Interconnection

The Spirit II system interconnection diagrams on the following pages will assist in the planning and installation of the system as well as identifying cables and hoses upon receipt.

The optional Inova torch height control is also shown to assist with its connections, whether as an external console or internal to the plasma power supply.

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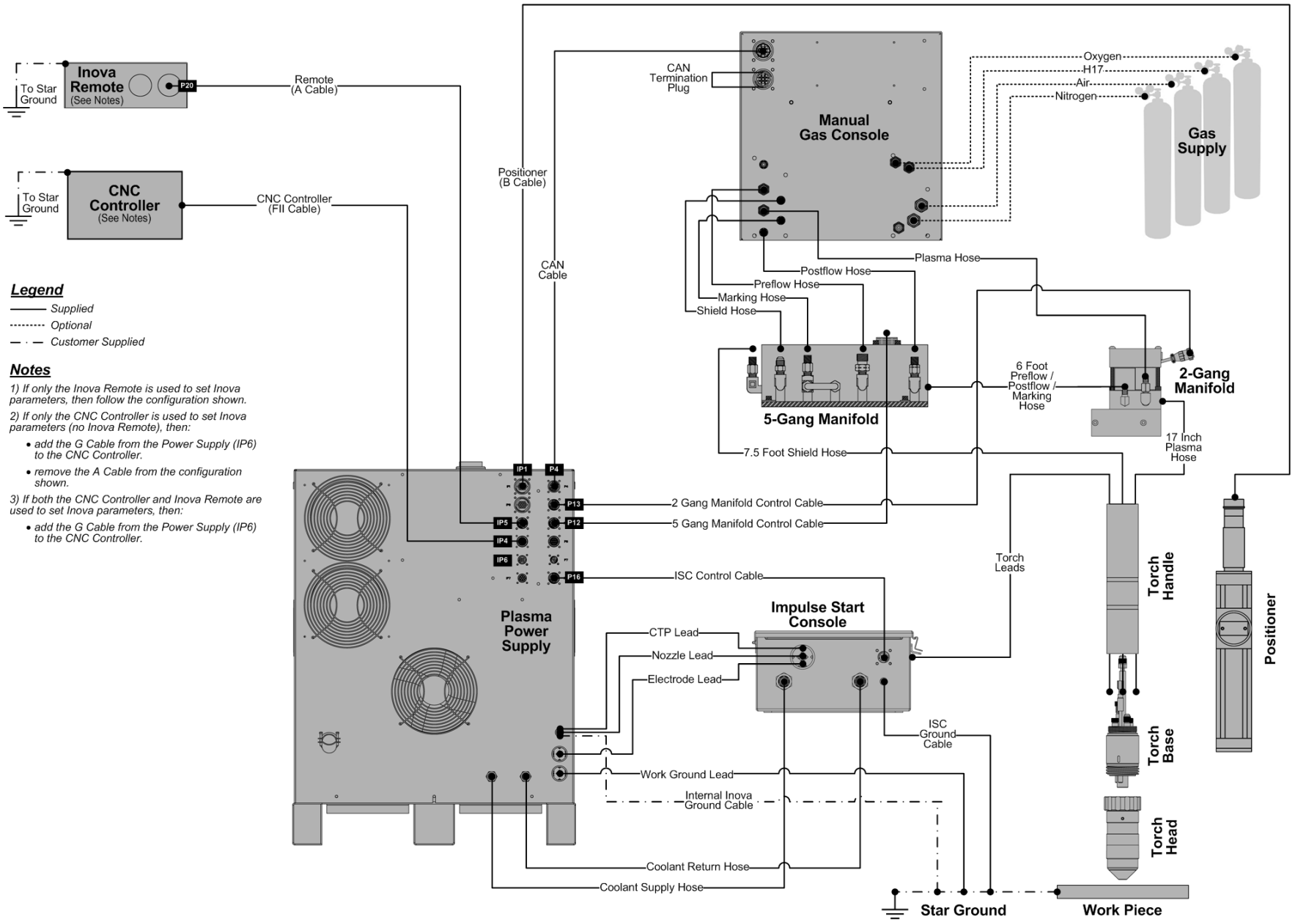

Figure 1: Spirit II System with Manual Gas Console and Internal Inova System

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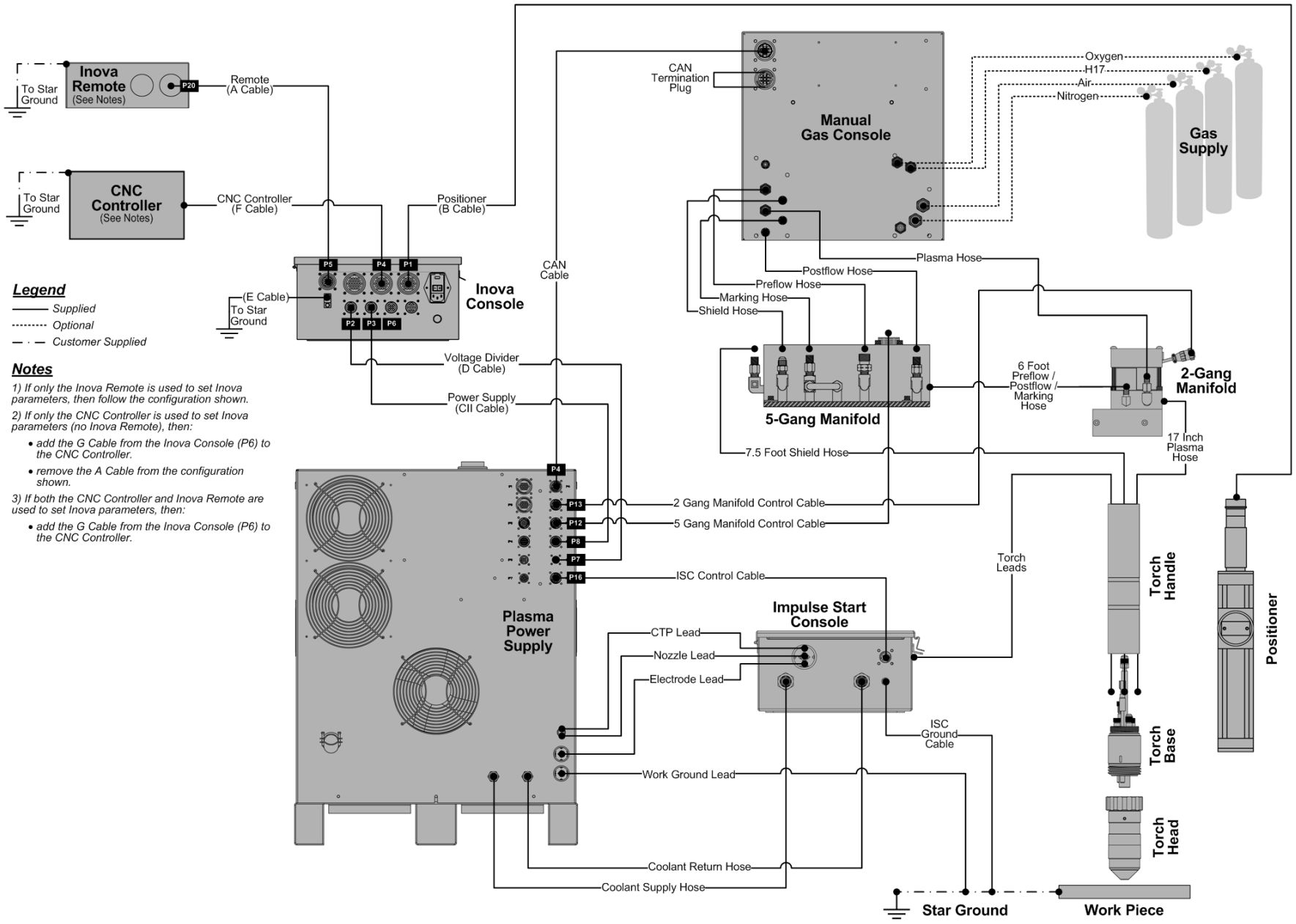

Figure 2: Spirit II System with Manual Gas Console and External Inova System

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Power Supply Primary Power Connections

**** Before connecting primary power, check the data plate on the power supply to verify the voltage required ****

A primary disconnect switch, switching all ungrounded supply conductors, should be provided for each Spirit system. The disconnect switch should be located as close as possible to the power supply so it can be turned off quickly in case of an emergency. **The disconnect switch should be equipped with time delay fuses only**. The magnetic inrush current of the power supply will cause fast acting fuses to blow. The disconnect switch should be sized according to local and national codes. The rating must meet or exceed the continuous rating of the fuses used. See the following chart for recommended fuse sizes:

3 Phase Input Voltage (VAC)	Input Current at Maximum Output (amps)	Recommended Time-Delay Fuse Size (amps)
208 VAC, 60Hz	99	125
220 VAC, 60Hz	94	125
240 VAC, 60Hz	86	110
380 VAC, 50/60Hz	54	65
400 VAC, 50/60Hz	52	65
415 VAC, 50/60Hz	50	60
440 VAC, 50/60Hz	47	60
480 VAC, 60Hz	43	60
600 VAC, 60Hz	34	45

Connection to the supply circuit can be by means of flexible supply cables or supply cables through conduit to a permanent installation. The supply cables should have a 600 volt minimum rating and should be sized according to local and national codes.

Route flexible supply cables through the strain relief on the back of the power supply and connect to the input terminal block TB5 as shown. For supply cables through conduit, install the conduit in place of the strain relief and connect the associated supply cables to the input terminal block TB5. See Figure 3 on the next page.

TB5 is located on the rear of the power supply and is accessible with the right-side cover removed. **Be sure to connect the primary ground cable to the ground stud on the input terminal block**.

Under no circumstances are the supply cables to be routed through the opening in the power supply cabinet without conduit or an appropriate strain relief as per local and national codes.

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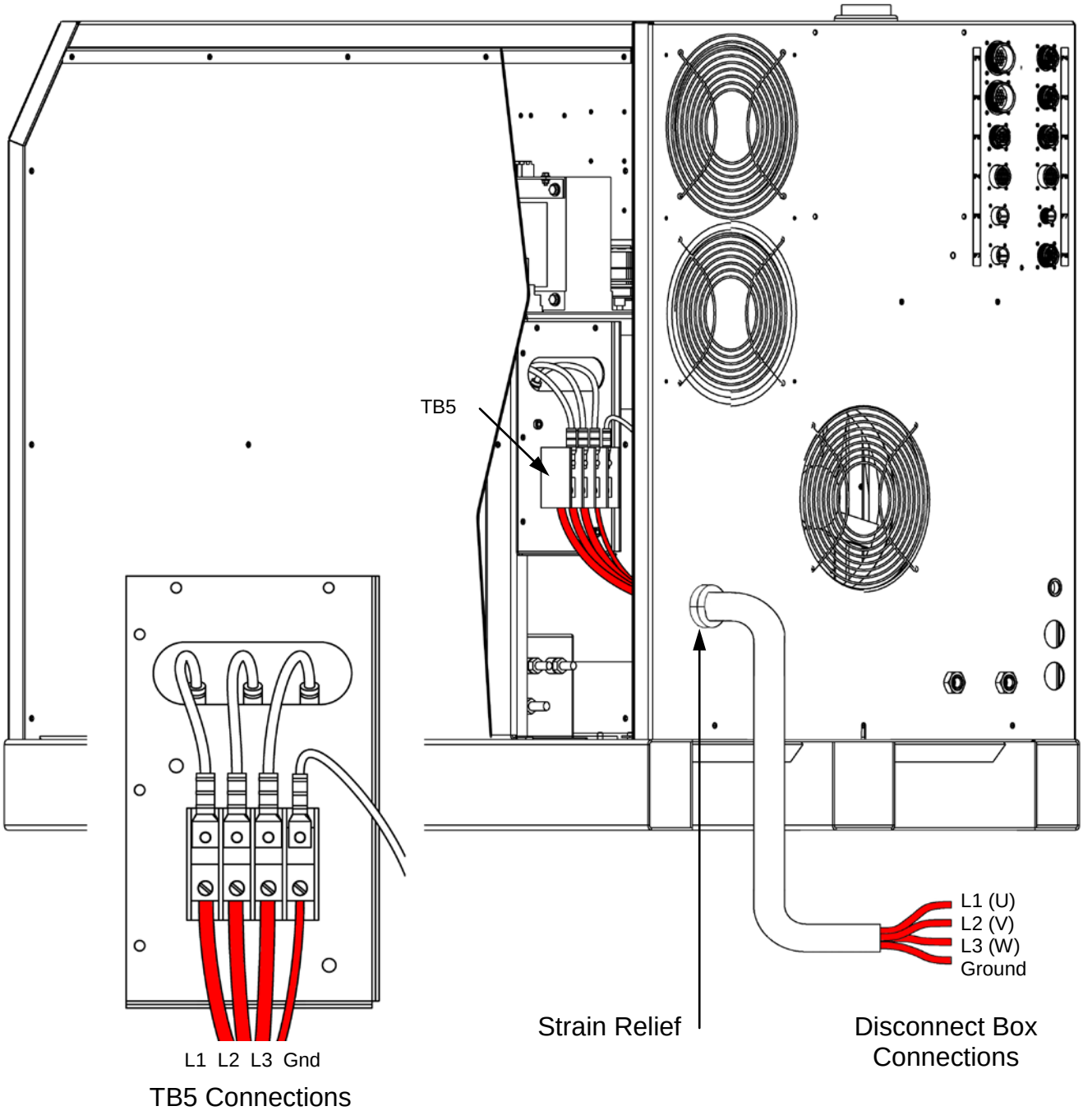

Figure 3: Power Supply Primary Connections

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Power Supply Output Connections

Perform the following steps to connect the output of the power supply to the impulse start console and the work table. See Figure 4 on the next page.

Power Supply Electrode Lead (1)

1. Route one end of the #1/0AWG power supply electrode lead through the upper strain relief on the rear of the power supply and connect it to the electrode terminal.
2. Route the other end of the power supply electrode lead through the strain relief on the impulse start console and connect it to the cathode manifold.

Power Supply Nozzle Lead (2)

1. Route the larger ring terminal end of the #10AWG power supply nozzle lead through the bushing on the rear of the power supply and connect it to the nozzle terminal.
2. Route the smaller ring terminal end of the power supply nozzle lead through the strain relief on the impulse start console and connect it to the pilot terminal on the printed circuit board.

Power Supply CTP Sensor Lead (3)

1. Route the ring terminal end of the #14AWG power supply CTP sensor lead through the bushing on the rear of the power supply and connect it to the CTP terminal.
2. Route the FASTON end of the power supply CTP sensor lead through the strain relief on the impulse start console and connect it to the CTP sensor lead with FASTON connector.

Work Ground Lead (4)

1. Route one end of the #1/0AWG work ground lead through the bottom strain relief on the rear of the power supply and connect it to the work terminal.
2. Connect the other end of the work ground lead to the star ground point on the cutting table.

   The star ground point is generally referred to as the common ground point on the cutting table where all subsystems of the machine are grounded. This point is then connected to a driven earth ground rod that should be as close as possible to the star ground. The ground rod should have no other wires connected to it. The ground rod should be at least 3/4 inches in diameter and should be driven into the earth's permanent moisture layer. The length of the ground rod varies from installation to installation and should be installed according to local and national codes. Refer to the National Electrical Code, Article 250, Section H, Ground Electrode System for additional information.

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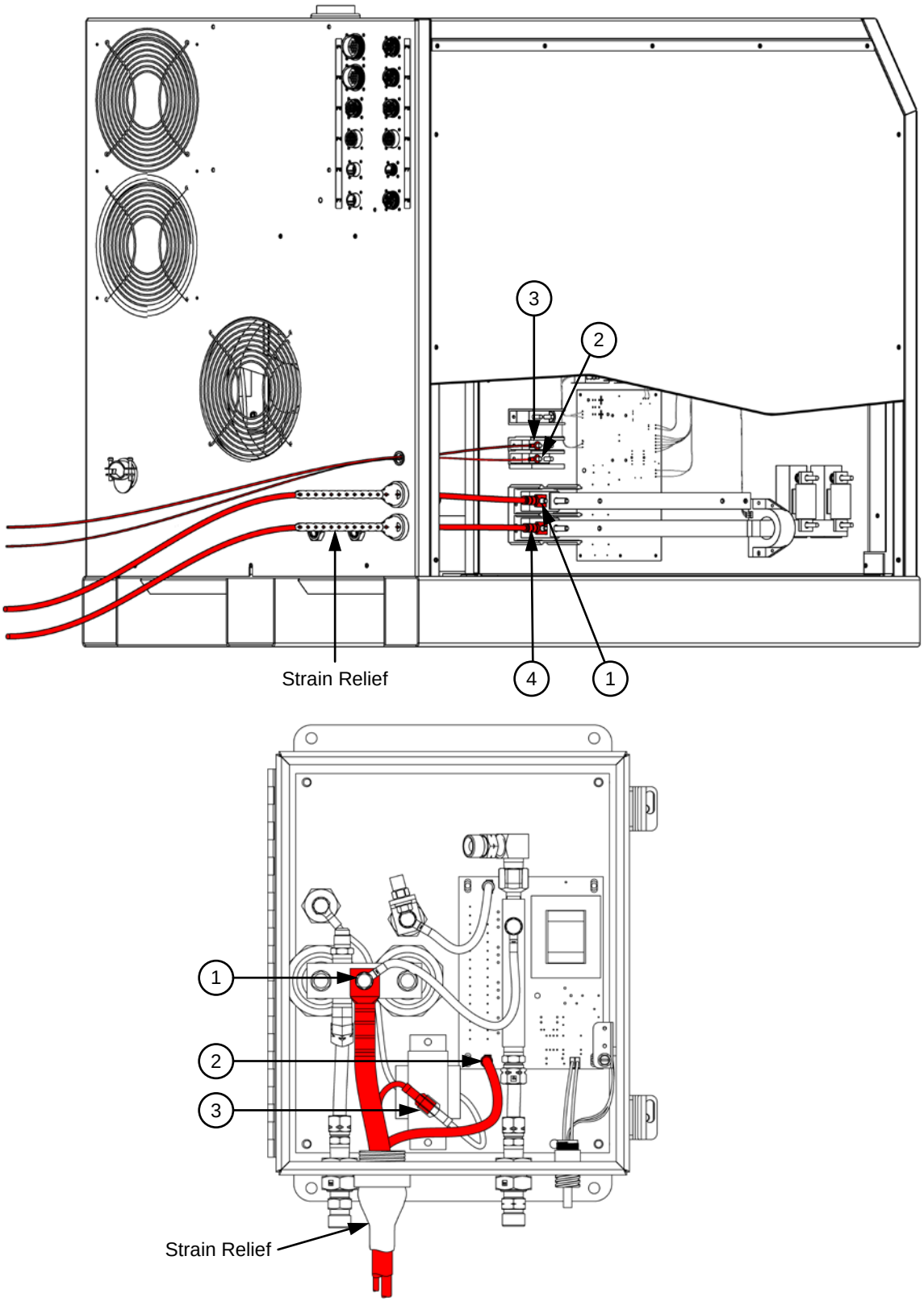

Figure 4: Power Supply Output Connections

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ISC Control Cable and ISC Ground Connections

Perform the following steps to connect the ISC control cable and ISC ground. See Figure 5 on the next page.

ISC Control Cable (5)

1. Connect the ISC control cable plug labeled P16 to the connector labeled P16 on the rear of the power supply.
2. Connect the ISC control cable plug labeled P1 to the connector labeled P1 on the impulse start console.

ISC Ground Cable (6)

1. Connect one end of the ISC ground cable to the ground stud on the impulse start console.
2. Connect the other end of the ISC ground cable to the star ground on the cutting table. Make sure that good metal-to-metal contact is made.

Cooling System Connections

Perform the following steps to connect the cooling system to the impulse start console. See Figure 5 on the next page.

Coolant Supply Hose (7)

1. Connect one end of the coolant supply hose to the coolant out fitting on the rear of the power supply. Note that the coolant out fitting has right hand threads.
2. Connect the other end of the coolant supply hose to the coolant in fitting on the impulse start console. Note that the coolant in fitting has right hand threads.

Coolant Return Hose (8)

1. Connect one end of the coolant return hose to the coolant in fitting on the rear of the power supply. Note that the coolant in fitting has left hand threads.
2. Connect the other end of the coolant return hose to the coolant out fitting on the impulse start console. Note that the coolant out fitting has left hand threads.

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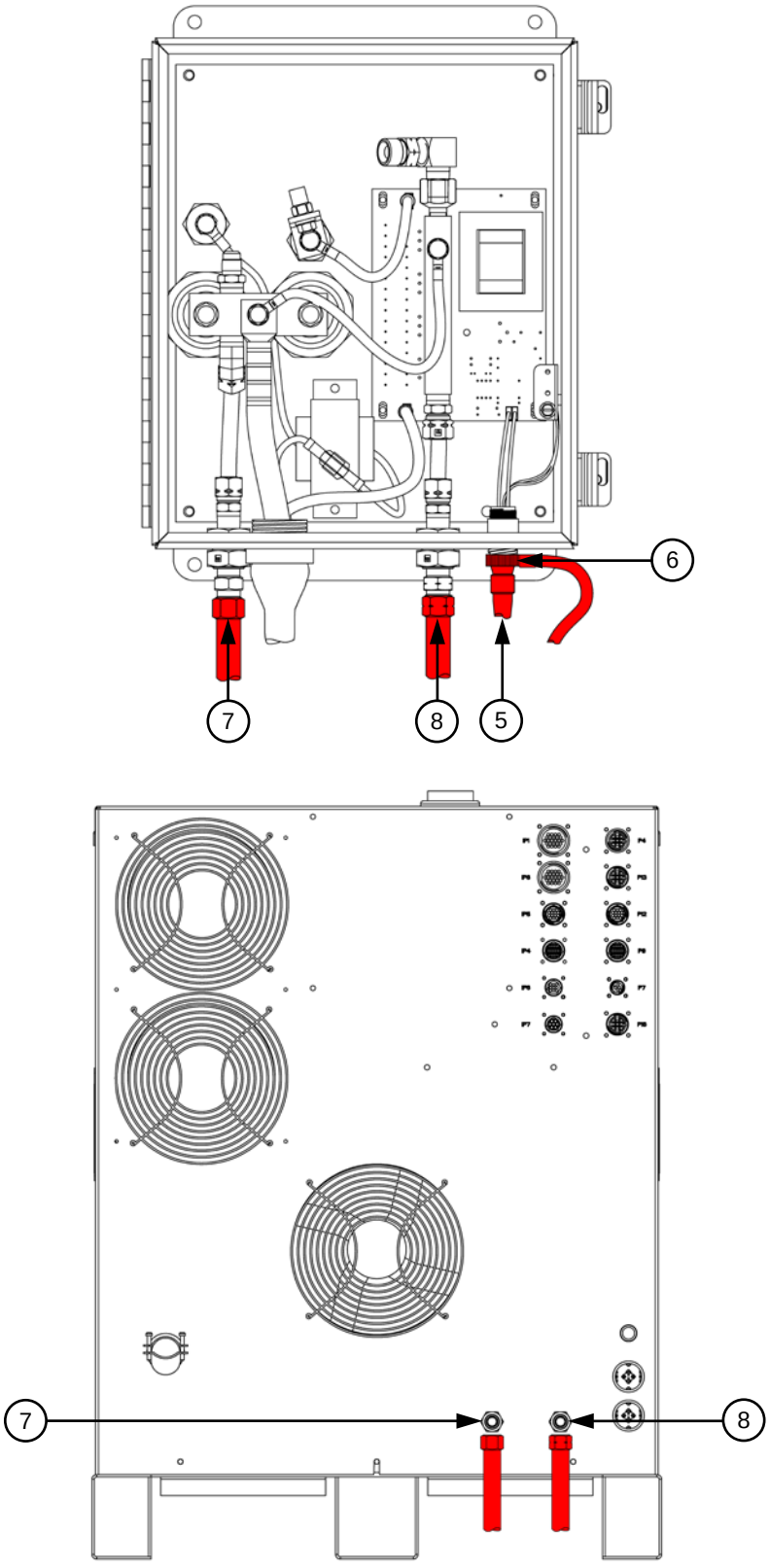

Figure 5: Cooling System Connections

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Torch Leads to Impulse Start Console Connections

Perform the following steps to connect the torch leads to the impulse start console. See Figure 6 on the next page.

Note: When making hose connections, only tighten the brass fittings enough to make water or gas seals. The fittings are subject to damage if over tightened.

Braided Shield (11)

1. Remove the threaded ring from the brass shield connector on the end of the braided shield. Route the torch leads through the opening in the impulse start console and push the shield connector through the hole until it is seated against the side of the console.
2. Slide the threaded ring over the torch leads, thread it onto the brass shield connector, and **tighten firmly**. The shield connector should ground the braided shield to the case of the impulse start console in order to help reduce high frequency noise emission. Using an ohmmeter, measure for zero ohms between the braided shield and the ground stud located on the outside of the impulse start console.

Torch Electrode/Coolant Supply Lead (12)

- Connect the torch electrode/coolant supply lead to the brass cathode manifold. Note that the torch electrode/coolant supply lead has right hand threads.

Torch Coolant Return Lead (13)

- Connect the torch coolant return lead to the brass cathode manifold. Note that the torch coolant return lead has left hand threads.

Torch Nozzle Lead (14)

- Connect the torch nozzle lead to the angled bracket on the red standoff. Note that the torch nozzle lead has right hand threads.

Torch CTP Sensor Lead (15)

- Connect the #18AWG torch CTP sensor lead to the red standoff as shown.

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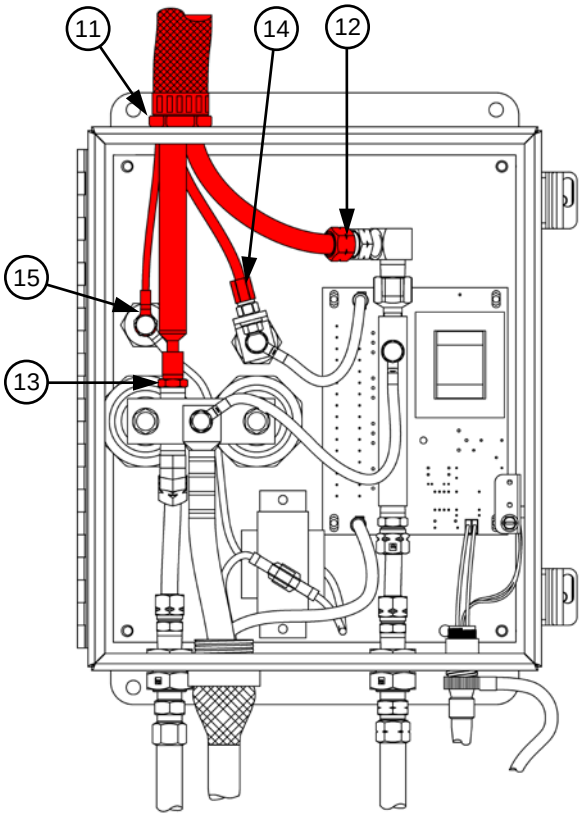

Figure 6: Torch Leads to Impulse Start Console Connections

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Torch Leads to Torch Base Connections

Perform the following steps to connect the torch leads to the torch base.

Note: When making hose connections, only tighten the brass fittings enough to make water or gas seals. The fittings are subject to damage if over tightened. Also, use two wrenches when tightening the torch fittings to avoid damaging the torch base.

Torch Lead through Torch Handle Installation

- Route the torch leads through the torch handle. Note that the threaded end of the torch handle mates with the torch base.

Torch Electrode/Coolant Supply Lead (16)

- Connect the torch electrode/coolant supply lead to the torch base as shown.

Torch Coolant Return Lead (17)

- Connect the torch coolant return lead to the torch base as shown. Note that the torch coolant return lead fitting has left hand threads.

Torch Nozzle Lead (18)

- Connect the torch nozzle lead to the torch base as shown.

Torch CTP Sensor Lead (19)

- Connect the torch CTP sensor lead to the torch base as shown.

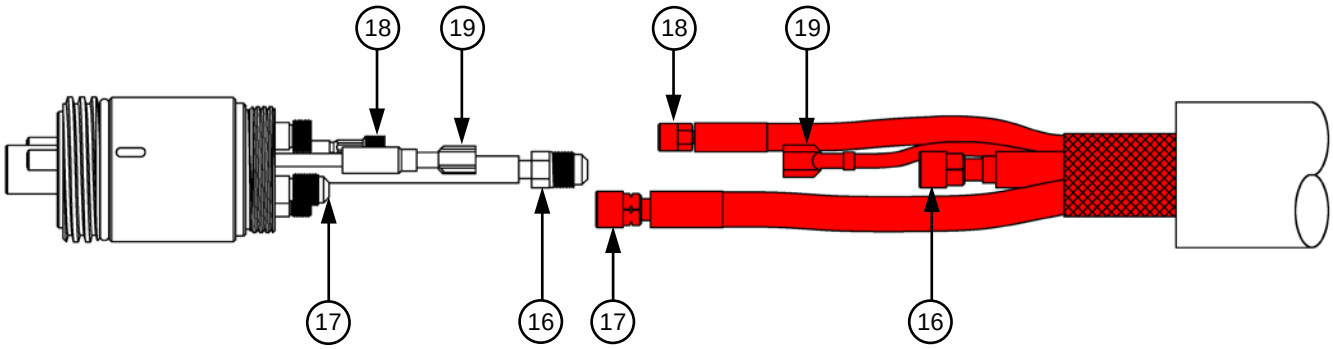

Figure 7: Torch Leads to Torch Base Connections

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Torch Gas Connections

Perform the following steps to connect the torch gas hoses to the manual gas console, torch base, and manifold assemblies. See figure 8.

Note: When making hose connections, only tighten the brass fittings enough to make gas seals. The fittings are subject to damage if over tightened.

7.5 Foot Shield Gas Hose (20)

1. Route one end of the 7.5 foot (2.3 m) shield gas hose through the torch handle and connect to the shield gas fitting on the torch base.
2. Connect the other end of the 7.5 foot (2.3 m) shield gas hose to the shield gas outlet on the 5-gang manifold.

17 Inch Plasma Gas Hose (21)

1. Route one end of the 17 inch (432 mm) plasma gas hose through the torch handle and connect to the plasma gas fitting on the torch base.
2. Thread the torch handle onto the torch base, being careful not to twist the torch leads and gas hoses when tightening the torch handle.
3. Tighten the base to the handle using a pin style adjustable spanner wrench (fits 2" diameter with ¼" diameter pin).
4. Attach the 2-gang manifold assembly to the torch handle. The top of the manifold bracket should be flush with the top of the torch handle.
5. Connect the other end of the 14 inch (432 mm) plasma gas hose to the plasma gas outlet on the 2-gang manifold.
6. Mount the torch handle/base/manifold to the positioner. Note the alignment indicators on the torch base (slot) and torch head (circle). These aid in aligning the quick-disconnect torch base and head and should be oriented so they are clearly visible when the operator is changing heads.

6 Foot Preflow/Postflow/Marking Gas Hose (22)

1. Connect one end of the 6 foot (1.8 m) preflow/postflow/marking gas hose to the preflow/postflow/marking outlet on the 5-gang manifold.
2. Connect the other end of the 6 foot (1.8 m) preflow/postflow/marking gas hose to the preflow/postflow/marking inlet on the 2-gang manifold.

Marking Gas Hose (23)

1. Connect one end of the marking shield gas hose to the marking shield outlet on the rear of the MGC.
2. Connect the other end of the marking shield gas hose to the marking shield inlet on the 5-gang manifold.

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Postflow Gas Hose (25)

1. Connect one end of the postflow hose to the postflow outlet on the rear of the MGC. Note that the postflow hose fittings have left hand threads.
2. Connect the other end of the postflow hose to the postflow inlet on the 5-gang manifold.

Plasma Gas Hose (26)

1. Connect on end of the plasma hose to the plasma outlet on the rear of the MGC.
2. Connect the other end of the plasma hose to the plasma inlet on the 2-gang manifold.

Shield Gas Hose (27)

1. Connect one end of the shield hose to the shield outlet on the rear of the MGC.
2. Connect the other end of the shield hose to the shield inlet on the 5-gang manifold.

Preflow Gas Hose (28)

1. Connect one end of the preflow hose to the preflow outlet on the rear of the MGC. Note that the preflow hose fittings have left hand threads.
2. Connect the other end of the preflow hose to the preflow inlet on the 5-gang manifold.

5-Gang Manifold Control Cable (29)

1. Connect the 5-gang manifold control cable plug marked P15 to the 5-gang manifold as shown.
2. Connect the 5-gang manifold control cable plug labeled P12 to the connector labeled P12 on the rear of the power supply.

2-Gang Manifold Control Cable (30)

1. Connect the 2-gang manifold control cable plug marked P18 to the 2-gang manifold as shown.
2. Connect the 2-gang manifold control cable plug labeled P13 to the connector labeled P13 on the rear of the power supply.

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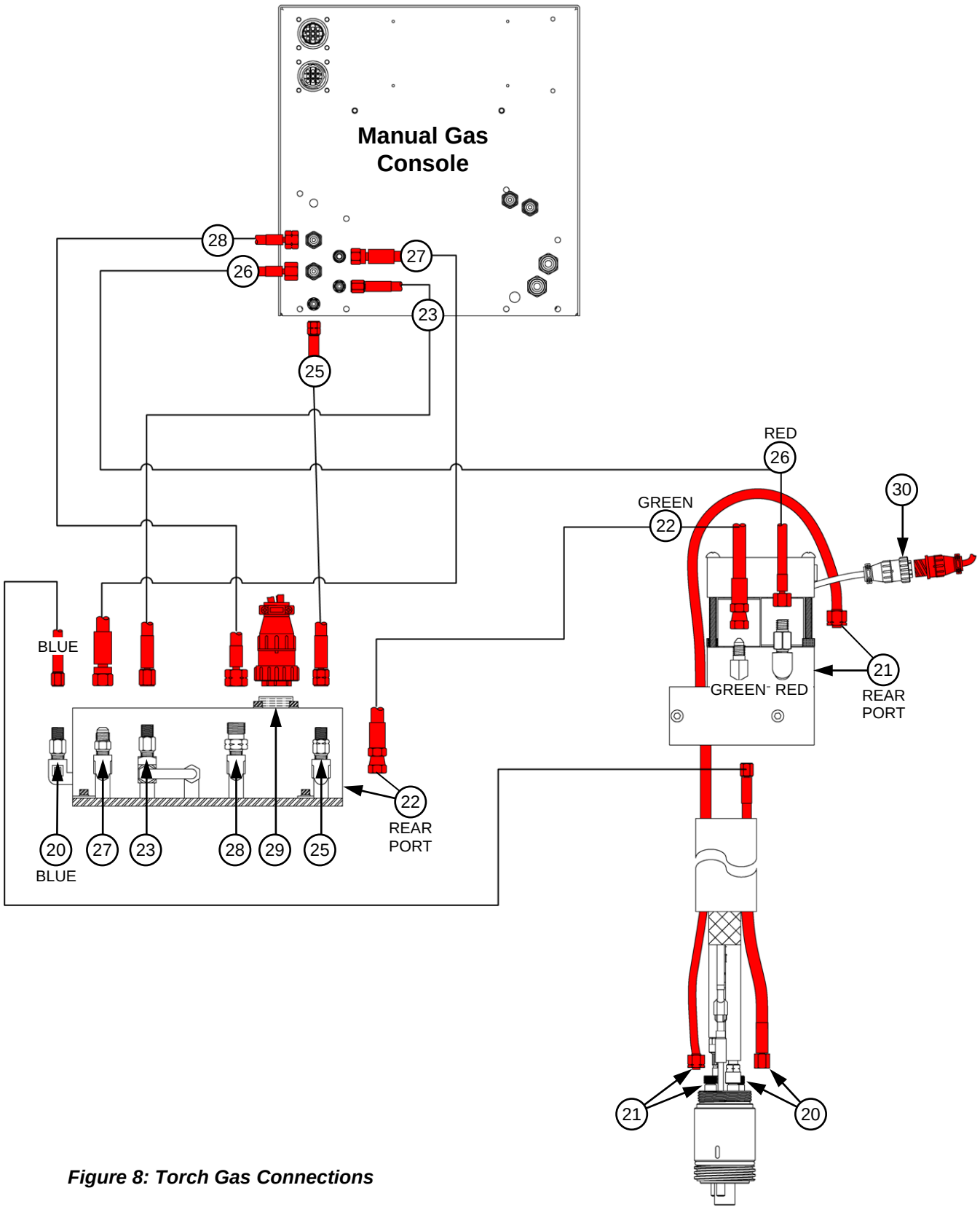

Figure 8: Torch Gas Connections

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Gas Supply Connections

Perform the following steps to connect the gas supply lines to the MGC. See Section 2 for gas supply requirements. Mating hose barbs and connectors are supplied with the system and are sized for 3/8 inch inside diameter hose. **Do not change the inlet gas supply fittings to quick-connect fittings. Using quick-connect fittings to connect and disconnect pressurized hoses may cause damage to the system.**

Note: When making hose connections, only tighten the brass fittings enough to make gas seals. The fittings are subject to damage if over tightened.

Air Inlet (31) (ISO 3821 hose color - black)

- Air must be supplied to the unit at all times, regardless of the cutting current or material type.

Oxygen Inlet (32) (ISO 3821 hose color - blue)

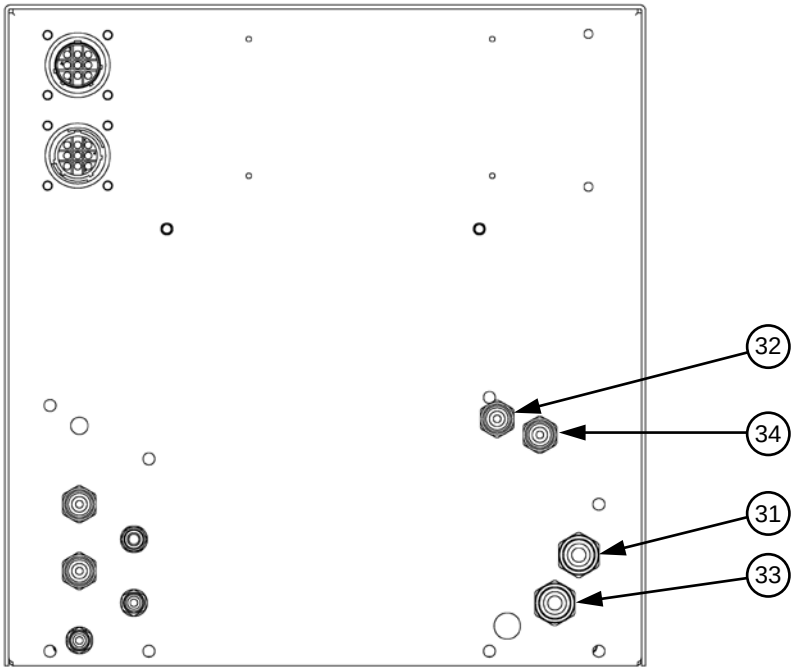
- Oxygen must be supplied to the unit at all times, unless stainless steel is being cut with H17 plasma.

Nitrogen Inlet (33) (ISO 3821 hose color - black)

- Nitrogen must be supplied to the unit at all times, regardless of the cutting current or material type.

H17 Inlet (34) (ISO 3821 hose color - red)

- H17 must be supplied to the unit when stainless steel is being cut with H17 as the plasma gas. See cutting charts in Section 5 for more information.



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CAN Communication Connections

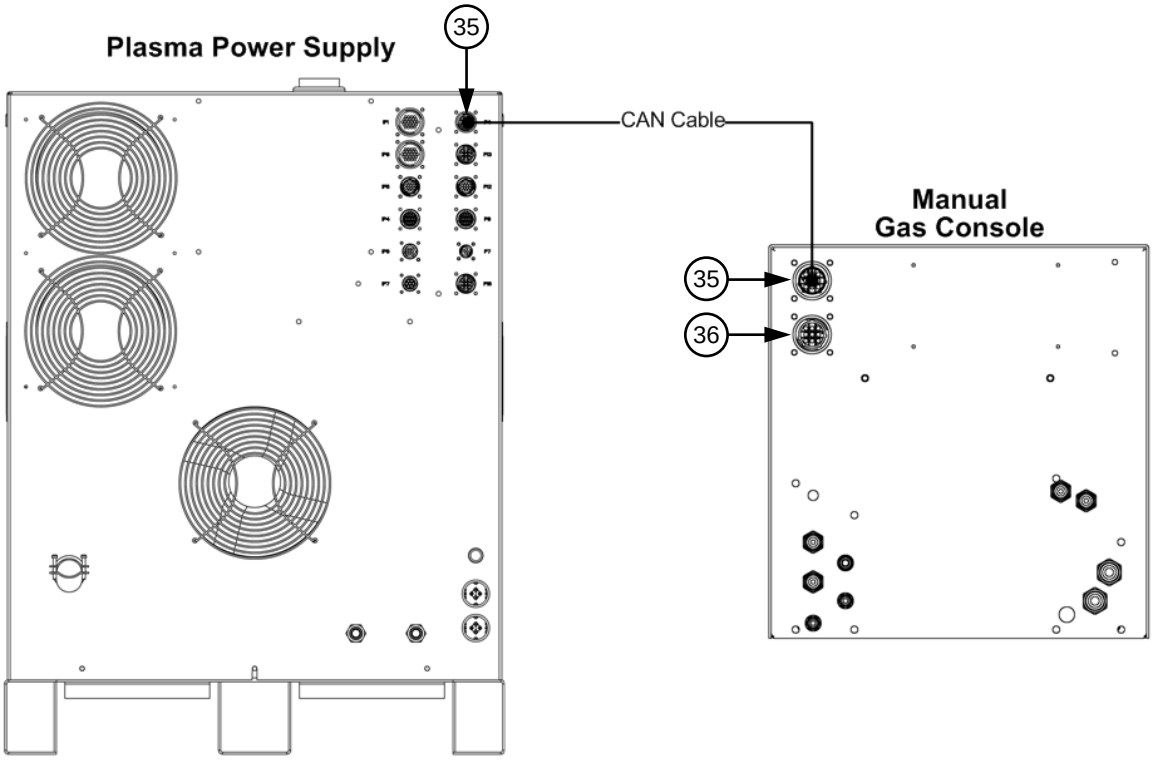
Perform the following steps to connect the plasma power supply to the MGC.

CAN Cable (35)

- Connect the male end of the CAN cable to the connector labeled P4 on the rear of the plasma power supply.
- Connect the female end of the CAN cable to the top connector on the rear of the MGC.

CAN Termination Plug (36)

- If not already installed, connect the CAN termination plug to the bottom connector on the rear of the MGC.



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CNC Machine Interface Connections

Perform the following steps to properly interface the Spirit system with a CNC cutting machine. See the system schematic for additional information.

Plasma Start Input
The power supply requires a contact closure between P8 pins 3 and 4 to commence the cutting or marking sequence. The sequence is terminated when the contacts are opened. The contacts should be rated for 24VDC - 7.3mA.

Plasma Cut/Mark Input
The power supply requires a contact closure between P8 pins 1 and 2 to put the system in plasma marking mode. Opening the contacts puts the system in cutting mode. The operating mode should be selected prior to applying a start signal. The contacts should be rated for 24VDC - 7.3mA.

Arc Hold Input
The power supply requires a contact closure between P8 pins 10 and 11 to inhibit arc starting even though a plasma start signal has been applied to the unit. When the contacts are opened, the arc is initiated. This feature is used to decrease cycle time by allowing pre-cut gas and contact sequencing to occur simultaneously with initial torch height positioning. The contacts should be rated for 24VDC - 7.3mA.

Motion Output
The power supply provides a maintained contact closure output between P8 pins 12 and 14 as long as an arc is maintained between the torch and the workpiece. The motion contacts are rated for 24VDC – 10mA.

Remote On/Off Input
The power supply requires a maintained contact closure between P8 pins 5 and 6 to energize the system from a remote location, provided that the OFF Button on the manual gas console is released. The contacts should be rated for 24VAC – 10mA. Opening the contacts deenergizes the system. If the remote on/off feature is to be used, remove the jumper between positions 1 and 2 on the J17 connector on the microprocessor DSP board.

Power Supply Ready Output
The power supply provides a maintained contact closure output between P8 pins 7 and 8 when the system is ready to cut or mark. The contacts are open during gas purge or when an error occurs. The contacts are rated for 24VDC – 10mA.

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Filling the Cooling System

⚠ ***WARNING: Do not touch the fans inside the power supply.***

Important: Never turn on the system when the coolant reservoir is empty.
Important: When handling coolant, wear nitrile gloves and safety glasses.
Important: Only use Kaliburn approved coolant. Commercially available antifreeze contains corrosion inhibitors that will damage the cooling system. See Section 2 for more information.

1. Remove primary power from the Spirit system.
2. Ensure the torch base and torch head (with consumables) are properly installed.
3. Ensure the coolant supply (in and out) hoses are properly installed.
4. Remove the coolant reservoir cap/level gauge and then remove the top, left and right covers from the power supply.
5. Ensure the coolant filter housing is tightened securely.
6. Ensure the drain petcock on the bottom of the reservoir is tightened securely.
7. Fill the reservoir with approximately 2 ½ gallons of approved coolant.
8. Apply primary power to the Spirit system and enable it by releasing (turn right) the OFF Button on the MGC.
9. On the MGC main menu, move the pointer to On. Press SELECT to start the coolant pump circulating coolant through the system. Note: The coolant pump will turn off automatically if the coolant level drops below the minimum level inside the reservoir. If this happens, add more coolant.
10. With the coolant pump running, locate the small red push-button on top of the coolant filter housing (beneath the reservoir). Press and hold the red button until no air or bubbles are seen inside the filter housing. Dry any coolant that leaks out.
11. Check for coolant leaks at all hose connections, the impulse start console, and at the torch.
12. Push the OFF Button on the MGC to stop the coolant pump.
13. Remove primary power from the Spirit system.
14. Fill the reservoir with coolant until the coolant gauge indicates full.
15. Replace the power supply covers and replace the coolant reservoir cap/level gauge.
16. End of procedure.

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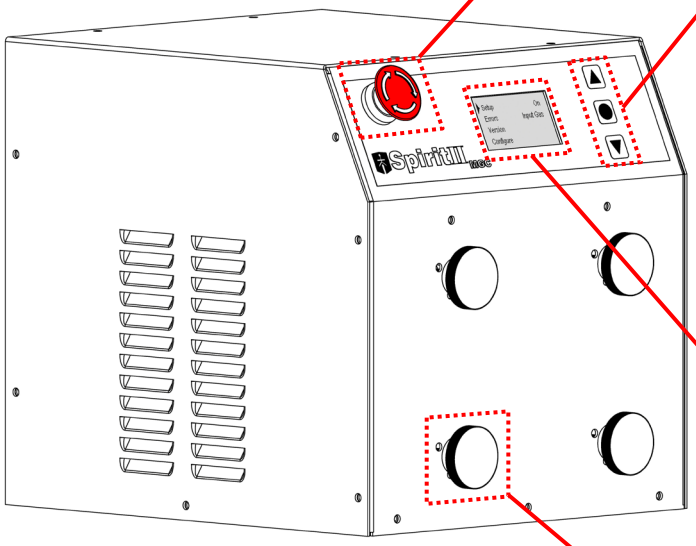
Section 4: Operation

Operating the Manual Gas Console (MGC)

The Manual Gas Console (MGC) is the interface to the entire Spirit system when the MGC is used instead of the Automatic Gas Console (AGC).



OFF Button
Push to disable the Spirit system. Release (turn to the right) to enable the system, which can then be energized by choosing ON and then SELECT.

Up/Down/Select Buttons
Press the up or down button to move the pointer ( ) accordingly on the display. These buttons are represented as UP and DOWN throughout this manual.

Press the select button ● to access menu items or settings identified by the pointer. This button is shown as SELECT throughout this manual.

Display
The display turns on automatically when AC power is applied to the Spirit system. It displays the menu tree, which is navigated using the Up/Down/Select buttons and is used to control the entire Spirit system.

Pressure Regulator Knobs
Turn to the left or right to adjust the amount of output gas pressure for PreFlow, PostFlow, Plasma and Shield gases.

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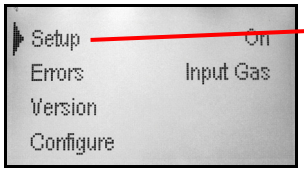
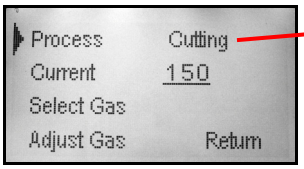
Setting up to Cut

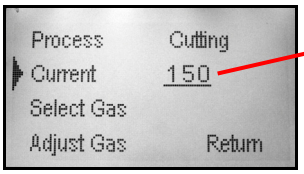
The following procedure uses the information from the cutting charts in Section 5 to prepare the system to cut. Press the UP or DOWN button on the MGC to move the pointer through the menu as described below.



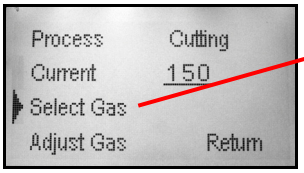
Push the **OFF Button** on the MGC to disable the system. On the main menu, move the pointer to **Setup**. Press SELECT.



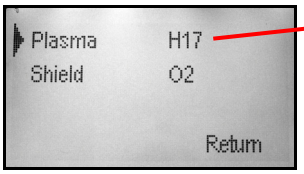
Press SELECT to cycle through the list until **Cutting** is displayed.



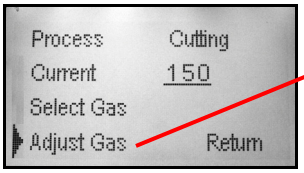
Move the pointer to **Current**.
Press SELECT to cycle through the list until the desired amperage is displayed.



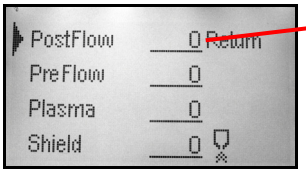
Move the pointer to **Select Gas**.
Press SELECT.



Press SELECT to choose the **Plasma** gas. Move the pointer to **Shield** and press SELECT to choose the shield gas. Move the pointer to **Return** and press SELECT.



Move the pointer to **Adjust Gas**.
Press SELECT.



Move the pointer to a gas and then press SELECT to start the flow of that gas. Turn the corresponding regulator knob on the MGC to adjust the displayed pressure to match the value in the cutting chart. Repeat for all other gases. Move the pointer to **Return** and press SELECT. Repeat to return to the main menu.

The system is now setup to cut.

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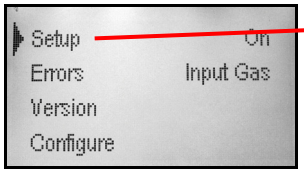
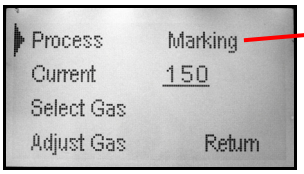
Setting up to Mark (Overrides Cut)

The system will automatically switch between cutting and marking based upon commands in the part program. However, all cutting commands in the part program can be overridden with marking commands by simply changing the **Process** to **Marking**.



Push the **OFF Button** on the MGC to disable the system. On the main menu, move the pointer to **Setup**. Press SELECT.

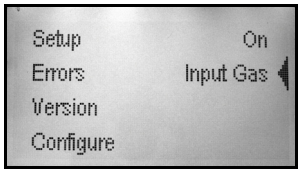


Press SELECT to cycle through the list until **Marking** is displayed. Move the pointer to **Return** and press SELECT.

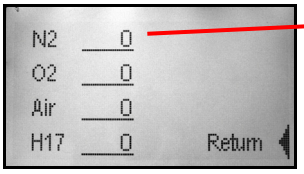
The system is now setup to mark instead of cut.

Verifying Input Gas Pressures

For the system to work properly the input gas pressures must be within an acceptable range. To check the input pressures, follow the steps below.



On the main menu, move the pointer to **Input Gas**. Press SELECT.



Verify that all connected gas pressures are at least 120psi. The maximum input gas pressure is 145psi.

Press SELECT to return to the main menu.

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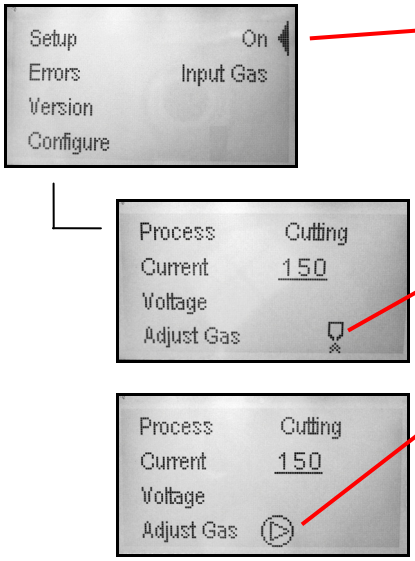
Making a Cut or Mark

Once the process type, gas types and gas pressures have been set in the MGC; the correct torch parts (consumables) installed; and the X/Y controller and torch height control are properly configured; the system is ready to cut or mark.



Release the **OFF Button** (turn to the right) on the MGC. On the main menu, move the pointer to **On**. Press SELECT.

The MGC will purge the gas hoses. The purge icon ( ) is displayed during this process.

Once purging is complete, the ready icon ( ) is displayed. The system is now ready to cut or mark.

When the system receives a start signal from the X/Y controller, the following sequence is initiated:

- Two second gas preflow
- Impulse start circuit energized
- Pilot arc initiation
- Transferred arc (cutting or marking arc) established
- Motion output relay energized

When the start signal is removed, the arc is extinguished and the motion output relay is deenergized.

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Piercing Thick Materials

Care must be taken when piercing thick materials in order to prevent damage to the shield cap and nozzle. As with all thicknesses, the pierce height must be set high enough so the metal ejected while piercing does not come into contact with the shield cap. Also, some of the material ejected during the pierce may adhere to the top side of the plate and form a ring of solidified material around the pierce point.

Action must be taken so the torch does not move from the pierce height down to the cutting height and come into contact with this solidified metal. The torch should not move from the pierce height down to the cutting height until the X/Y controller has moved the torch away from the pierce point.

One way to accomplish this may be to program the pierce time on the torch height control system to a value that is longer than the X/Y controller motion delay time.

Moving Pierces and Edge Starts

On very thick materials, an edge start or moving pierce may be required to prevent damage to the torch consumables.

With a moving pierce, the X/Y machine should begin moving at approximately 5–10 inches/minute (125–250 mm/min) as soon as the arc transfers to the plate. After the arc completely penetrates the plate, the torch should be positioned at the proper cutting height and the X/Y machine speed should be increased to the correct level.

With an edge start the torch should be positioned at the edge of the material prior to starting the arc.

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Cut Quality

Before the optimum cutting condition can be achieved on a particular material type and thickness, the machine operator must have a thorough understanding of the cutting characteristics of the Spirit system. When the cut quality is not satisfactory, the cutting speed, torch height, or gas pressures may need to be adjusted in small increments until the proper cutting condition is obtained. The following guidelines should be useful in determining which cutting parameter to adjust.

Note: Before making any parameter changes, verify that the torch is square to the workpiece. Also, it is essential to have the correct torch parts in place and to ensure that they are in good condition. Check the electrode for excessive wear and the nozzle and shield cap orifices for roundness. Also, check the parts for any dents or distortions. Irregularities in the torch parts can cause cut quality problems.

1. A positive cut angle (top dimension of piece smaller than the bottom dimension) usually occurs when the torch standoff distance is too high, when cutting too fast, or when excessive power is used to cut a given plate thickness.

2. A negative cut angle (top dimension of piece larger than the bottom dimension) usually occurs when the torch standoff distance is too low or when the cutting speed is too slow.

3. Top dross usually occurs when the torch standoff distance is too high.

4. Bottom dross usually occurs when the cutting speed is either too slow (slow-speed dross) or too fast (high-speed dross). Low-speed dross is easily removed, while high-speed dross usually requires grinding or chipping off. When using oxygen as the shielding gas, bottom dross can sometimes be removed by increasing the shield gas pressure. However, increasing the shield pressure too much can cause cut face irregularities (see below). Bottom dross also occurs more frequently as the metal heats up. As more pieces are cut out of a particular plate, the more likely they are to form dross.

5. When using oxygen as a shielding gas, cut face irregularities usually indicate that the shield gas pressure is too high or the torch standoff distance is too low.

6. A concave cut face usually indicates that the torch standoff distance is too low or the shield gas pressure is too high. A convex cut face usually indicates that the torch standoff distance is too high or the shield gas pressure is too low.

7. Note that different material compositions have an effect on dross formation.

8. If the material is not being completely severed, the likely causes are that the cutting current is too low, the travel speed is too high, the gas pressures are incorrect, the incorrect gas types are selected, the incorrect consumables are installed in the torch, or the consumables are worn.

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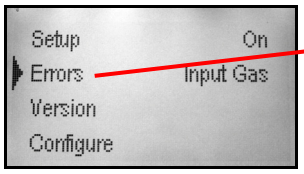
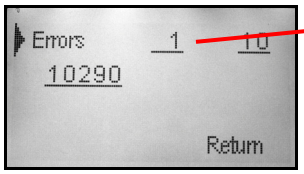
Checking Errors

The last ten (10) system errors are available through the MGC as described below.



On the main menu, move the pointer to **Errors**. Press SELECT.



Press SELECT to cycle through the last ten (10) error codes.

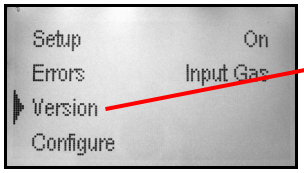
See Section 6 in this manual for details on the error codes.

Simultaneously pressing DOWN and SELECT will erase all ten error codes.

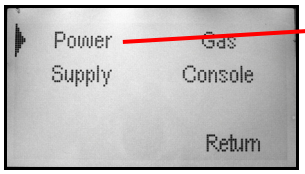
Move the pointer to **Return** and press SELECT to return to the main menu.

Checking the Version and Serial Number

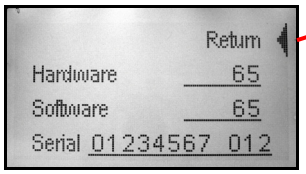
The hardware version, software version and serial number for the Power Supply and Gas Console can be displayed as described below.



On the main menu, move the pointer to **Version**. Press SELECT.



Move the pointer to either **Power Supply** or **Gas Console**. Press SELECT.



Review the necessary information.

Press SELECT to return to the previous screen.

Move the pointer to **Return** and press SELECT to return to the main menu.

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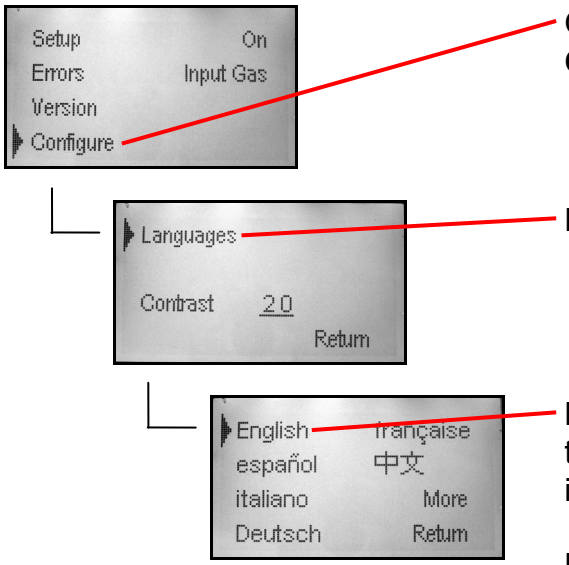
Changing the Language

The language displayed on the MGC can be changed as described below.



On the main menu, move the pointer to **Configure**. Press SELECT.

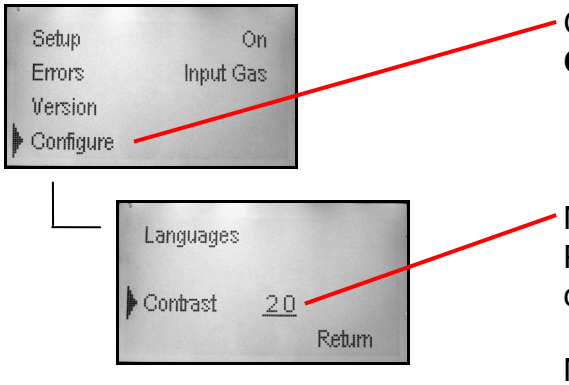
Press SELECT on **Languages**.

Move the pointer to the desired language and then press SELECT. The display changes immediately to the selected language.

Move the pointer to **Return** and press SELECT to return to the previous screen. Repeat to return to the main menu.

Adjusting the Screen Contrast

The contrast of the display on the MGC can be adjusted as described below.



On the main menu, move the pointer to **Configure**. Press SELECT.

Move the pointer to **Contrast**.
Press SELECT to cycle through the list of contrast settings.

Move the pointer to **Return** and press SELECT to return to the main menu.

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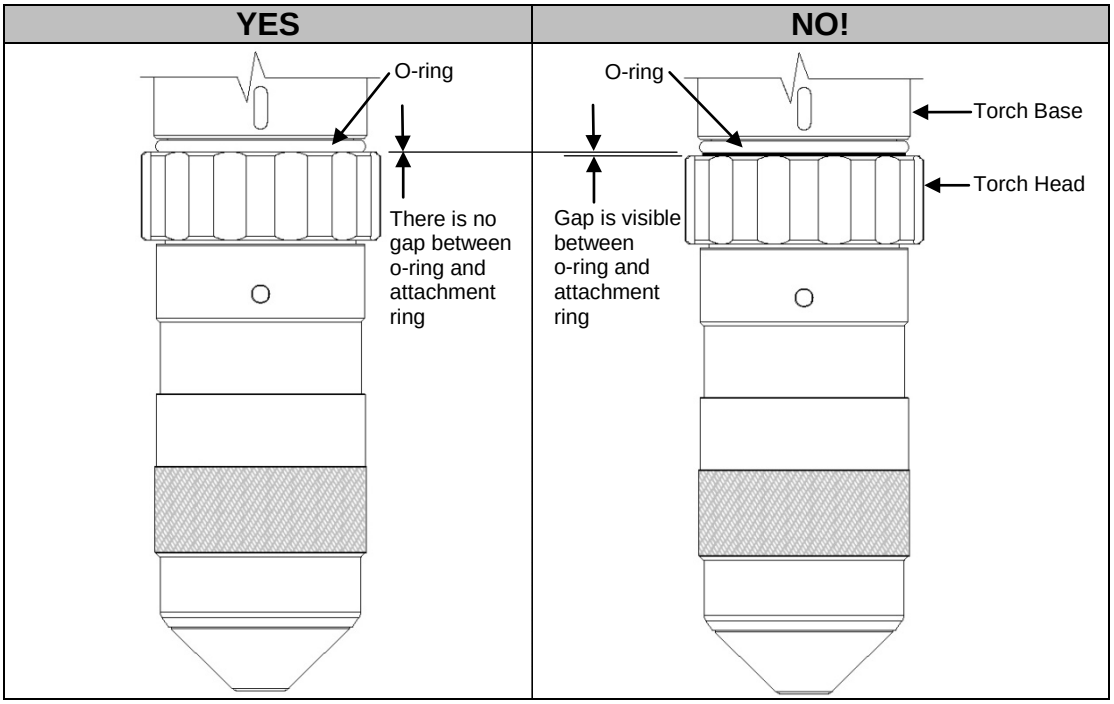
Section 5: Torch Consumables and Cutting Charts

Installing / Removing the Torch Head

⚠ **WARNING: Remove primary power from the Spirit system!**

1. Each time the torch head is connected to the torch base, use a cotton swab to apply a small amount of o-ring lubricant on each of the seven o-rings on the top of the torch head. **Reminder: do not use an excessive amount of o-ring lubricant.**
2. Align the indicator on the torch head (circle) with the one on the torch base (slot).
3. Apply enough upward force to engage the threads while tightening the attachment ring. Turn the attachment ring to the RIGHT to tighten.
4. Keep tightening the attachment ring until it stops. There should be no gap between the attachment ring and the o-ring on the torch base.

   During this process, a small amount of coolant will collect in the torch head. It is normal for this coolant to discharge between the o-ring on the torch base and the attachment ring while the system is being pressurized. If coolant continues to discharge after the system is pressurized, turn off the plasma power supply, remove the torch head and inspect the o-rings for damage.



To remove the torch head, turn the attachment ring to the LEFT.

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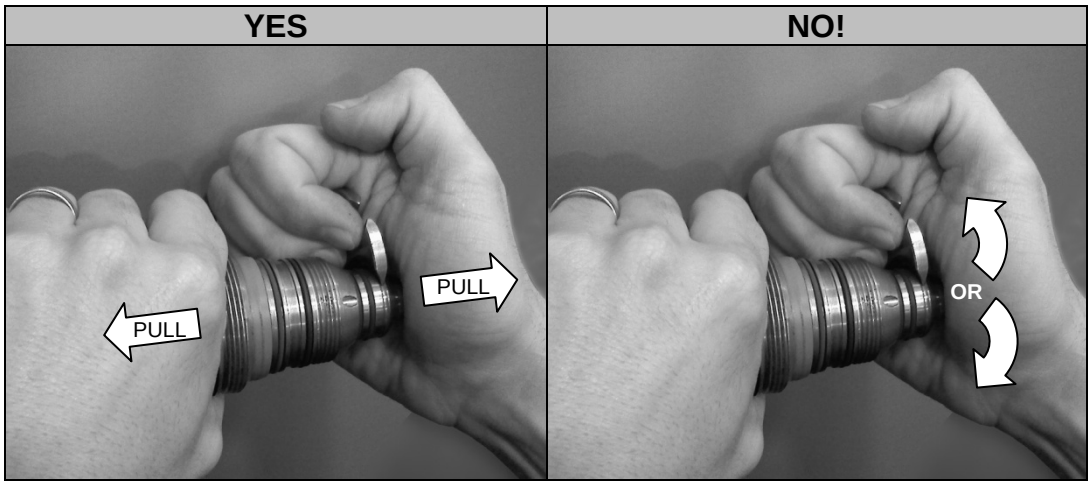
Installing / Replacing Consumables

⚠ **WARNING: Remove primary power from the Spirit system!**

Note: When installing the consumables, do not use an excessive amount of o-ring lubricant. Also ensure that the lubricant is placed only on the o-rings. Excess lubricant can interfere with gas flow, which can cause starting problems, poor cut quality, and short consumable life.

1. Unthread the torch head from the torch base by turning the attachment ring to the LEFT. Verify the torch base doesn't unthread from the torch handle.
2. Remove the outer retaining cap from the torch head.
3. Remove the inner retaining cap from the torch head.
4. Separate the shield cap from either the inner retaining cap or the outer retaining cap.
5. Use the nozzle removal tool (P/N BK277056) to remove the nozzle from the torch head. To do this, insert the tool into the groove on the nozzle and hold the tool/nozzle in the palm of your hand. Pull both hands apart using a linear motion as shown in the left image below. Do not use a prying or bending motion as shown in the right image below.



6. Use the swirl ring removal tool (P/N BK260105) to remove the swirl ring from the nozzle.
7. Remove the electrode from the torch head using the appropriate tool:
   - All copper electrodes use socket P/N BK277087 & driver P/N BK277086.
   - All silver electrodes use P/N BK279061.
8. Inspect all consumables and o-rings for damage and excess wear. Replace with new consumables as necessary.
9. Inspect the cooling tube in the torch head for damage. See Section 6 Maintenance and Troubleshooting if replacement is necessary.

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Maximizing Consumable Life

Use the following guidelines to maximize consumable parts life:

1. The Spirit system utilizes the latest advancement in technology for extending the life of the torch consumable parts. To maximize the life of the consumable parts, it is imperative that the shutdown procedure of the arc is carried out properly. **The arc must be extinguished while it is still attached to the workpiece.** A popping noise may be heard if the arc extinguishes abnormally. Note that holes are usually programmed without lead-outs to prevent loss of the arc during shutdown. There is a time delay between the reception of a stop signal and when the arc is extinguished. During this time, the gases and cutting current are changed to optimum values for extinguishing the arc. Ideally, the x/y machine controller should provide a plasma stop signal prior to the end of the cut path so the gases and current reach the shut off values at the same time that the part has been completely cut. The shut down times are different for each current and are given below.

Arc Shutdown Times

Current (A)	Time (ms)
30	490
50	390
70	300
100	300
150	175

2. Use the recommended pierce height given in the cutting charts. A pierce height that is too low will allow molten metal that is ejected during the piercing process to damage the shield cap and nozzle. A pierce height that is too high will cause the pilot arc time to be excessively long and will cause nozzle damage. See "Piercing Thick Materials" in Section 4.
3. Never fire the torch in the air. Nozzle damage will occur.
4. Make sure the torch does not touch the plate while cutting. Shield cap and nozzle damage will result.
5. Use a chain cut when possible. Starting and stopping the torch is more detrimental to the consumables than making a continuous cut.
6. Always use error tracking on the plasma console to keep track of cut errors. See Section 4 for information on error tracking.

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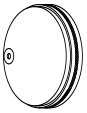
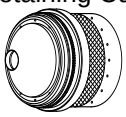
Inspecting for Damage

When the cut quality is not satisfactory, use the following guidelines for determining which consumable parts need to be changed. Inspect all parts for dirt, debris, and excess o-ring lubricant and clean as necessary.

Part	Inspect For	Corrective Action
Outer Cap	Dents, cracks	Replace outer cap
Shield Cap 	Center hole out of round	Replace shield cap
	Dents, Scratches	Replace shield cap
	Dry o-ring	Apply a thin film of o-ring lubricant
	Damaged o-ring	Replace shield cap
Retaining Cap 	Center hole out of round	Replace retaining cap
	Dents, cracks	Replace retaining cap
	Dry o-ring	Apply a thin film of o-ring lubricant
	Damage o-ring	Replace retaining cap
Nozzle	Center hole out of round	Replace nozzle
	Erosion or arcing	Replace nozzle
	Dry o-rings	Apply a thin film of o-ring lubricant
	Damaged o-rings	Replace nozzle
Swirl Ring	Damage	Replace swirl ring
	Clogged holes	Blow out with compressed air. Replace swirl ring if clogs can't be removed.
	Dry o-rings	Apply a thin film of o-ring lubricant
	Damaged o-rings	Replace swirl ring
Electrode or	Pit depth	Replace electrode if center pit depth is greater than 0.040" (1 mm) for copper electrode or 0.098" (2.5mm) for silver.
	Erosion or arcing	Replace electrode
	Dry o-rings	Apply a thin film of o-ring lubricant
	Damaged o-rings	Replace electrode

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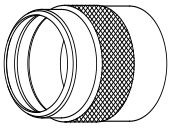
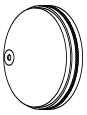
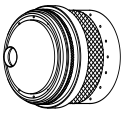
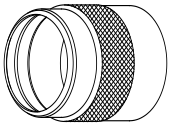
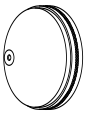
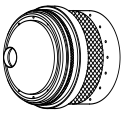
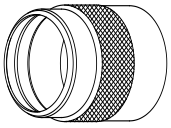
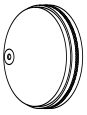
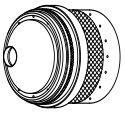
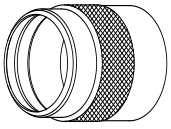
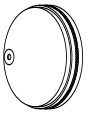
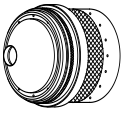
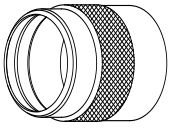
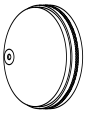
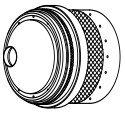
Selecting Consumables

Mild Steel
Copper Electrode

	Outer Retaining Cap	Shield Cap	Inner Retaining Cap	Nozzle	Swirl Ring	Copper Electrode	Torch Head
30A	BK284150 	BK277145 	BK277153 	BK277120	BK277140	BK277130	BK279100
50A	BK284150 	BK277115 	BK277153 	BK277122	BK277140/ BK277142	BK277131	BK279100
70A	BK284150 	BK277150 	BK277153 	BK277125	BK277142	BK277131	BK279100
100A	BK284150 	BK277286 	BK277151 	BK277284	BK277283	BK277282	BK279100
150A	BK284150 	BK277117 	BK277151/ BK277152 	BK277293	BK277139	BK277292	BK279100

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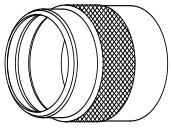
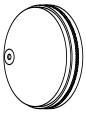
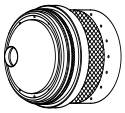
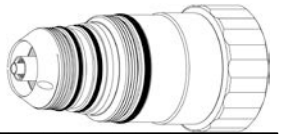
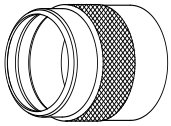
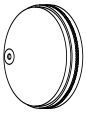
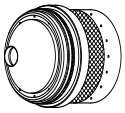
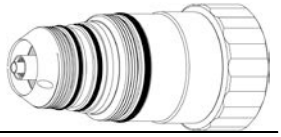
Mild Steel
Silver Electrode

	Outer Retaining Cap	Shield Cap	Inner Retaining Cap	Nozzle	Swirl Ring	Silver Electrode	Torch Head
100A	BK284150 	BK277286 	BK277151 	BK279484	BK279483	BK279410 (brown o-ring)	BK279060 
150A	BK284150 	BK277117 	BK277151/ BK277152 	BK279493	BK279439	BK279420 (green o-ring)	BK279060 

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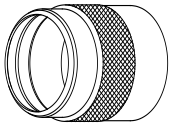
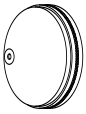
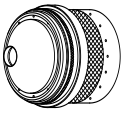
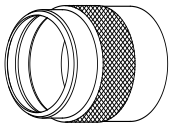
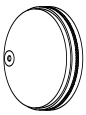
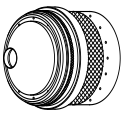
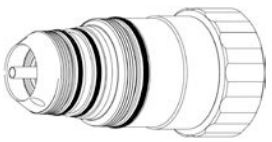
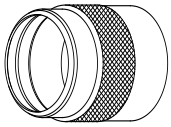
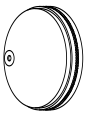
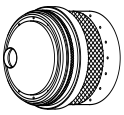
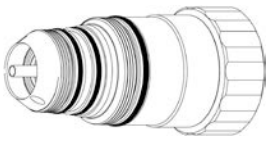
Stainless Steel - H17 Plasma
Copper Electrode

	Outer Retaining Cap	Shield Cap	Inner Retaining Cap	Nozzle	Swirl Ring	Copper Electrode	Torch Head
	BK284150	BK277150	BK277113	BK277124	BK277140	BK277132	BK279100
70A							
	BK284150	BK277146	BK277113	BK277126	BK277141	BK277133	BK279100
100A							
	BK284150	BK277298	BK277266	BK277297	BK277139	BK277135	BK279100
150A							

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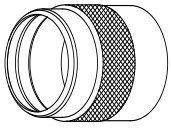
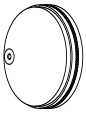
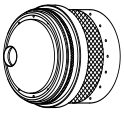
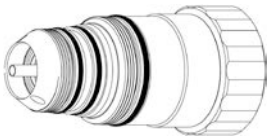
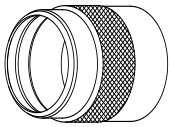
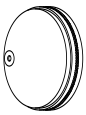
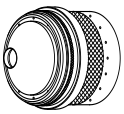
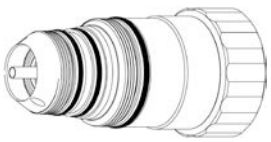
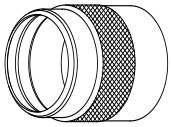
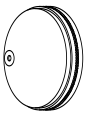
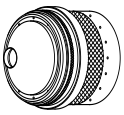
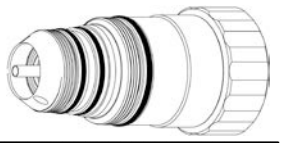
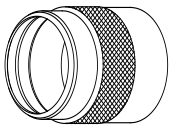
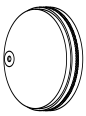
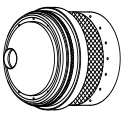
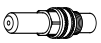
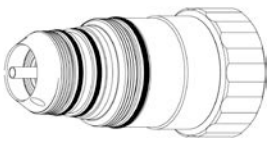
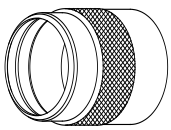
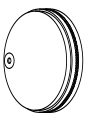
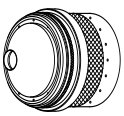
Stainless Steel - Air or Nitrogen Plasma
Copper Electrode

	Outer Retaining Cap	Shield Cap	Inner Retaining Cap	Nozzle	Swirl Ring	Copper Electrode	Torch Head
	BK284150	BK277144	BK277110	BK277121	BK277138	BK277137	BK279100
30A							
	BK284150	BK277149	BK277110	BK277123	BK277142	BK277137	BK279100
50A							
	BK284150	BK277150	BK277153	BK277125	BK277142	BK277131	BK279100
70A							
	BK284150	BK277286	BK277151	BK277284	BK277283	BK277282	BK279100
100A							
	BK284150	BK277117	BK277152	BK277293	BK277139	BK277292	BK279100
150A							

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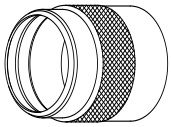
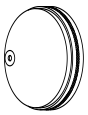
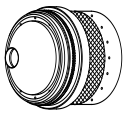
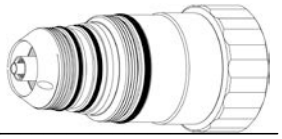
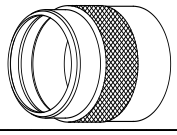
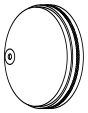
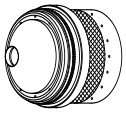
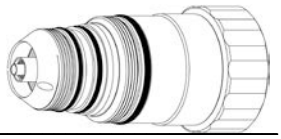
Stainless Steel - Air or Nitrogen Plasma
Silver Electrode

	Outer Retaining Cap	Shield Cap	Inner Retaining Cap	Nozzle	Swirl Ring	Silver Electrode	Torch Head
100A	BK284150 	BK277286 	BK277151 	BK279484	BK279483	BK279410 (brown o-ring)	BK279060 
150A	BK284150 	BK277117 	BK277152 	BK279493	BK279439	BK279420 (green o-ring)	BK279060 

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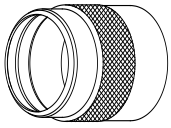
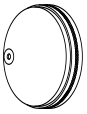
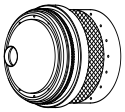
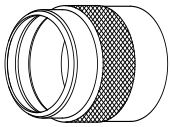
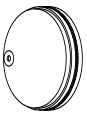
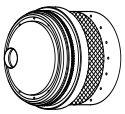
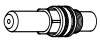
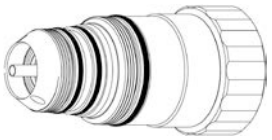
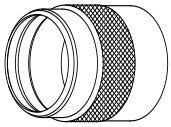
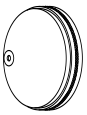
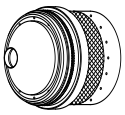
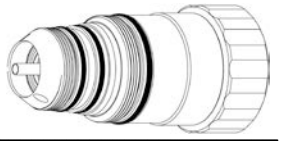
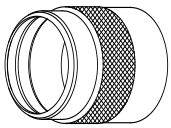
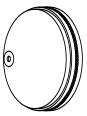
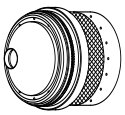
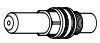
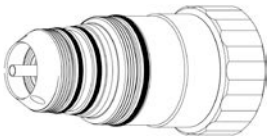
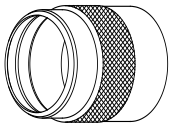
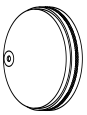
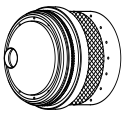
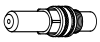
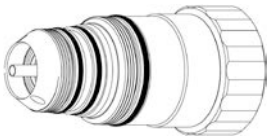
Aluminum
Copper Electrode

	Outer Retaining Cap	Shield Cap	Inner Retaining Cap	Nozzle	Swirl Ring	Copper Electrode	Torch Head
	BK284150	BK277145	BK277153	BK277120	BK277140	BK277130	BK279100
30A							
	BK284150	BK277150	BK277153	BK277122	BK277142	BK277131	BK279100
50A							
	BK284150	BK277150	BK277153	BK277125	BK277142	BK277131	BK279100
70A							
	BK284150	BK277286	BK277151	BK277284	BK277283	BK277282	BK279100
100A							
	BK284150	BK277117	BK277152	BK277293	BK277139	BK277292	BK279100
150A							

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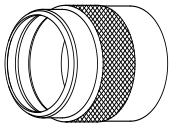
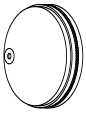
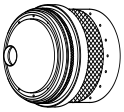
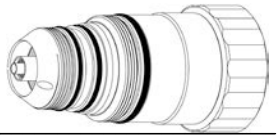
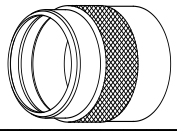
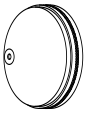
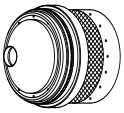
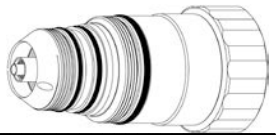
Aluminum
Silver Electrode

	Outer Retaining Cap	Shield Cap	Inner Retaining Cap	Nozzle	Swirl Ring	Silver Electrode	Torch Head
100A	BK284150 	BK277286 	BK277151 	BK279484	BK279483	BK279410 (brown o-ring)	BK279060 
150A	BK284150 	BK277117 	BK277152 	BK279493	BK279439	BK279420 (green o-ring)	BK279060 

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Cutting Charts

The cutting charts shown on the following pages are intended to give the operator the best starting point to use when making a cut on a particular material type and thickness. Small adjustments may have to be made to achieve the best cut. Also, remember that the arc voltage must be increased as the electrode wears in order to maintain the correct cutting height.

Cutting Chart Index

Material	Current	Plasma Gas	Shield Gas	Copper Electrode	Silver Electrode
Mild Steel	30 Amps	Oxygen	Oxygen	Page 5-13	
Mild Steel	50 Amps	Oxygen	Oxygen or Air	Page 5-14	
Mild Steel	70 Amps	Oxygen	Air	Page 5-15	
Mild Steel	100 Amps	Oxygen	Air	Page 5-16	Page 5-31
Mild Steel	150 Amps	Oxygen	Air	Page 5-17	Page 5-32
Stainless Steel	30 Amps	Air	Air	Page 5-18	
Stainless Steel	50 Amps	Air	Nitrogen	Page 5-19	
Stainless Steel	70 Amps	H17	Nitrogen	Page 5-20	
Stainless Steel	70 Amps	Air	Nitrogen	Page 5-21	
Stainless Steel	100 Amps	H17	Nitrogen	Page 5-22	
Stainless Steel	100 Amps	Air	Nitrogen	Page 5-23	Page 5-33
Stainless Steel	150 Amps	H17	Nitrogen	Page 5-24	
Stainless Steel	150 Amps	Air	Nitrogen	Page 5-25	Page 5-34
Aluminum	30 Amps	Air	Nitrogen	Page 5-26	
Aluminum	50 Amps	Air	Nitrogen	Page 5-27	
Aluminum	70 Amps	Air	Nitrogen	Page 5-28	
Aluminum	100 Amps	Air	Nitrogen	Page 5-29	Page 5-35
Aluminum	150 Amps	Air	Nitrogen	Page 5-30	Page 5-36

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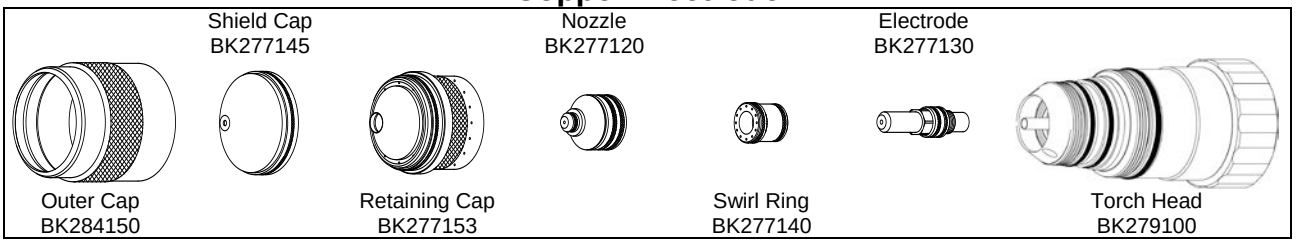
Mild Steel - 30 Amps - Oxygen Plasma / Oxygen Shield
Copper Electrode



Imperial*

Material Thickness		Preflow	Plasma	Shield	Postflow	Arc Voltage	Travel Speed	Cutting Height	Pierce Height	Pierce Time	Kerf Width
(ga)	(in)	(psi)	(psi)	(psi)	(psi)	(volts)	(ipm)	(in)	(in)	(msec)	(in)
20	.036	35	77	6	75	120	105	.080	.110	100	.062
18	.048					121	97	.090			
16	.060					125	78	.105		200	.065
14	.075					126	65				
12	.105					127	55				.070
11	.120					129	50	.120	.125	300	
10	.135					131	40				

Metric*

Material Thickness	Preflow	Plasma	Shield	Postflow	Arc Voltage	Travel Speed	Cutting Height	Pierce Height	Pierce Time	Kerf Width
(mm)	(psi)	(psi)	(psi)	(psi)	(volts)	(mm/m)	(mm)	(mm)	(msec)	(mm)
1	35	77	6	75	120	2615	2.0	2.8	100	1.6
1.5					124	2020	2.6		200	1.7
2					126	1615	2.7			
2.5						1455				1.8
3					128	1285	2.9	3.1	300	

Marking* – For All Material Thicknesses

Type of Gas		Preflow	Plasma	Shield	Postflow	Arc Voltage	Travel Speed		Marking Height		Initial Height		Pierce Time
(Plasma)	(Shield)	(psi)	(psi)	(psi)	(psi)	(volts)	(ipm)	(mm/min)	(in)	(mm)	(in)	(mm)	(msec)
Nitrogen	Nitrogen	N/A	25	25	N/A	145	250	6350	.177	4.5	.100	2.5	0
Argon**	Air**	N/A	50	25	N/A	66	100	2540	.100	2.5	.100	2.5	0

* Use an arc transfer height (ignition height) of .100" (2.5 mm) for cutting and marking.
** Only available on systems with the Automatic Gas Console.
(Revised 04/26/2013)

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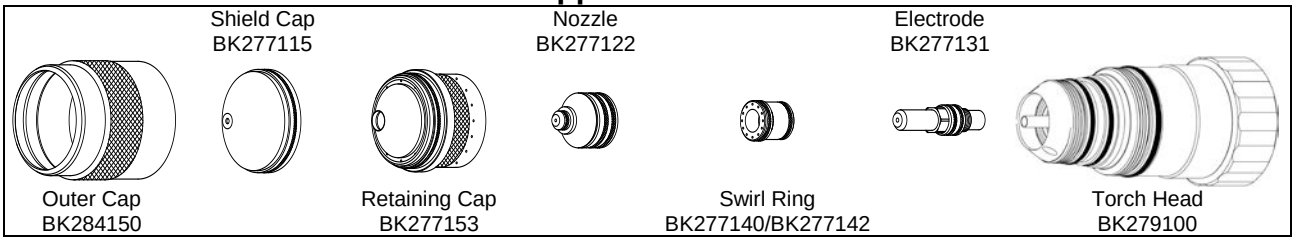
Mild Steel - 50 amps - Oxygen Plasma / Oxygen or Air Shield
Copper Electrode



Imperial*

Material Thickness (ga)	Material Thickness (in)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (ipm)	Cutting Height (in)	Pierce Height (in)	Pierce Time (msec)	Kerf Width (in)
Cold-Rolled Steel – Oxygen Shield – Swirl Ring BK277140											
12	.105	25	74	12	72	123	70	.120	.135	100	.075
11	.120					126	60	.125		200	.078
10	.135					128	50	.135			
Hot-Rolled Steel – Air Shield – Swirl Ring BK277142											
14	.075	25	74	19	72	106	200	.100	.135	100	.075
12	.105						190				
	.125						180			200	.080
10	.135					110	170	.110			
	3/16					113	105	.140	.200	300	.085
	1/4					117	75		.225	400	.087

Metric*

Material Thickness (mm)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (mm/m)	Cutting Height (mm)	Pierce Height (mm)	Pierce Time (msec)	Kerf Width (mm)
Cold-Rolled Steel – Oxygen Shield – Swirl Ring BK277140										
2.5	25	74	12	72	121	1895	2.9	3.4	100	1.9
3					125	1555	3.1		200	2.0
Hot-Rolled Steel – Air Shield – Swirl Ring BK277142										
2.5	25	74	19	72	106	4885	2.5	3.4	100	1.9
3						4660			200	2.0
5					113	2555	3.6	5.1	400	2.2
6					116	2075		5.5		

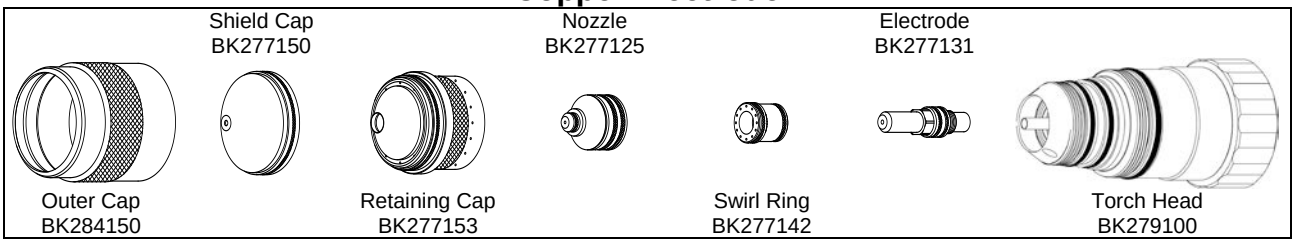
Marking* – For All Material Thicknesses

Type of Gas (Plasma)	Type of Gas (Shield)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (ipm)	Travel Speed (mm/min)	Marking Height (in)	Marking Height (mm)	Initial Height (in)	Initial Height (mm)	Pierce Time (msec)
Nitrogen	Nitrogen	N/A	25	25	N/A	145	250	6350	.147	3.7	.100	2.5	0
Argon**	Air**	N/A	50	25	N/A	71	100	2540	.100	2.5	.100	2.5	0

* Use an arc transfer height (ignition height) of .135" (3.4 mm) for cutting and .100" (2.5 mm) for marking.
** Only available on systems with the Automatic Gas Console.
(Revised 04/26/2013)

This information is subject to the controls of the Export Administration Regulations [EAR]. This information shall not be provided to non-U.S. persons or transferred by any means to any location outside the United States contrary to the requirements of the EAR.

Mild Steel - 70 Amps - Oxygen Plasma / Air Shield
Copper Electrode



Imperial*

Material Thickness (in)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (ipm)	Cutting Height (in)	Pierce Height (in)	Pierce Time (msec)	Kerf Width (in)
1/8	25	76	35	74	110	190	.100	.150	100	.080
3/16			40		113	130		.200	200	
1/4					116	120	.110	.225	300	.085
3/8					122	75	.140	.250	400	

Metric*

Material Thickness (mm)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (mm/m)	Cutting Height (mm)	Pierce Height (mm)	Pierce Time (msec)	Kerf Width (mm)
3	25	76	35	74	109	4995	2.5	3.6	100	2.0
5			40		113	3265		5.1	300	
6					115	3105	2.7	5.5		2.2

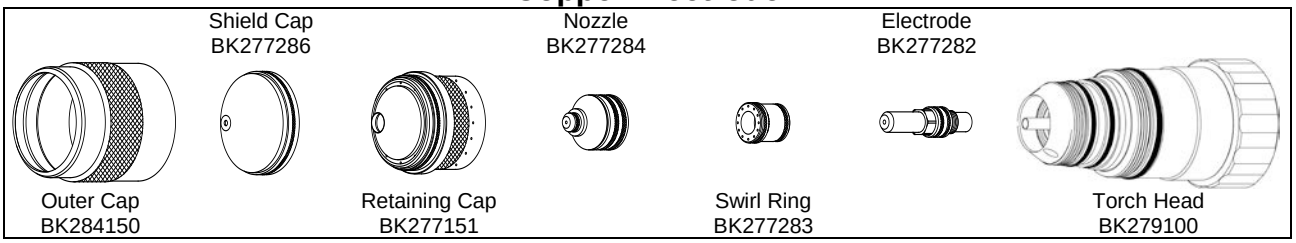
Marking* – For All Material Thicknesses

Type of Gas (Plasma)	Type of Gas (Shield)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (ipm)	Travel Speed (mm/min)	Marking Height (in)	Marking Height (mm)	Initial Height (in)	Initial Height (mm)	Pierce Time (msec)
Nitrogen	Nitrogen	N/A	25	25	N/A	135	250	6350	.096	2.4	.100	2.5	0
Argon**	Air**	N/A	50	25	N/A	62	100	2540	.100	2.5	.100	2.5	0

* Use an arc transfer height (ignition height) of .150" (3.8 mm) for cutting and .100" (2.5 mm) for marking.
** Only available on systems with the Automatic Gas Console.
(Revised 04/26/2013)

This information is subject to the controls of the Export Administration Regulations [EAR]. This information shall not be provided to non-U.S. persons or transferred by any means to any location outside the United States contrary to the requirements of the EAR.

Mild Steel - 100 Amps - Oxygen Plasma / Air Shield
Copper Electrode



Imperial*

Material Thickness (in)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (ipm)	Cutting Height (in)	Pierce Height (in)	Pierce Time (msec)	Kerf Width (in)
1/4	25	83	26	81	125	150	.090	.200	300	.090
3/8					130	100	.130	.250	400	
1/2						65	.155	.300	500	
5/8					143	47	.185	.325	800	.095
3/4					145	35		.350	1000	

Metric*

Material Thickness (mm)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (mm/m)	Cutting Height (mm)	Pierce Height (mm)	Pierce Time (msec)	Kerf Width (mm)
6	25	83	26	81	124	3950	2.1	4.9	300	2.3
10					130	2405	3.3	6.5	500	
12						1850	3.7	7.3		
16					143	1180	4.7	8.3	1000	2.4
20					145	800		9.0		

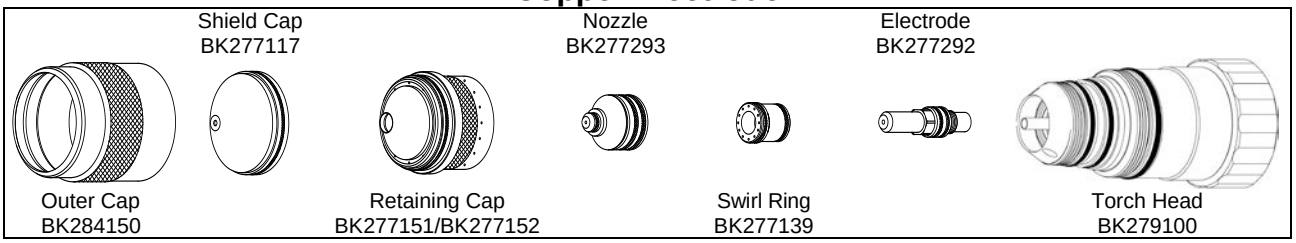
Marking* – For All Material Thicknesses

Type of Gas (Plasma)	Type of Gas (Shield)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (ipm)	Travel Speed (mm/min)	Marking Height (in)	Marking Height (mm)	Initial Height (in)	Initial Height (mm)	Pierce Time (msec)
Nitrogen	Nitrogen	N/A	25	25	N/A	130	250	6350	.100	2.5	.100	2.5	0
Argon**	Air**	N/A	50	25	N/A	60	100	2540	.100	2.5	.100	2.5	0

* Use an arc transfer height (ignition height) of .200" (5.1 mm) for cutting and .100" (2.5 mm) for marking.
** Only available on systems with the Automatic Gas Console.
(Revised 04/26/2013)

This information is subject to the controls of the Export Administration Regulations [EAR]. This information shall not be provided to non-U.S. persons or transferred by any means to any location outside the United States contrary to the requirements of the EAR.

Mild Steel - 150 Amps - Oxygen Plasma / Air Shield
Copper Electrode



Imperial*

Material Thickness (in)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (ipm)	Cutting Height (in)	Pierce Height (in)	Pierce Time (msec)	Kerf Width (in)
Retaining Cap BK277151										
1/4	20	71	30	69	118	165	.105	.200	300	.125
3/8					123	125	.135	.250	400	
1/2					125	90	.140	.300	500	.130
Retaining Cap BK277152										
5/8	20	71	45	69	127	70	.140	.325	600	.130
3/4					130	55		.350	1000	.135
1					134	40	.150	.400	1500	.140
1.25 ***					145	25	.200	.350		
1.50 ***					155	15	.225	.350		

Metric*

Material Thickness (mm)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (mm/m)	Cutting Height (mm)	Pierce Height (mm)	Pierce Time (msec)	Kerf Width (mm)
Retaining Cap BK277151										
6	20	71	30	69	117	4305	2.6	4.9	300	3.2
10					123	3040	3.4	6.5	500	
12					124	2485	3.5	7.3		3.3
Retaining Cap BK277152										
16	20	71	45	69	127	1760	3.6	8.3	1000	3.3
20					130	1340		9.0	1500	3.4
25					133	1040	3.7	10.1		3.6
32 ***					145	625	5.1	8.9		
38 ***					154	385	5.6	8.9		

Marking* – For All Material Thicknesses

Type of Gas (Plasma)	Type of Gas (Shield)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (ipm)	Travel Speed (mm/min)	Marking Height (in)	Marking Height (mm)	Initial Height (in)	Initial Height (mm)	Pierce Time (msec)
Nitrogen	Nitrogen	N/A	25	25	N/A	135	250	6350	.100	2.5	.100	2.5	0
Argon**	Air**	N/A	50	25	N/A	61	100	2540	.100	2.5	.100	2.5	0

* Use an arc transfer height (ignition height) of .200" (5.1 mm) for cutting and .100" (2.5 mm) for marking.
** Only available on systems with the Automatic Gas Console.
*** Edge start recommended.
(Revised 04/26/2013)

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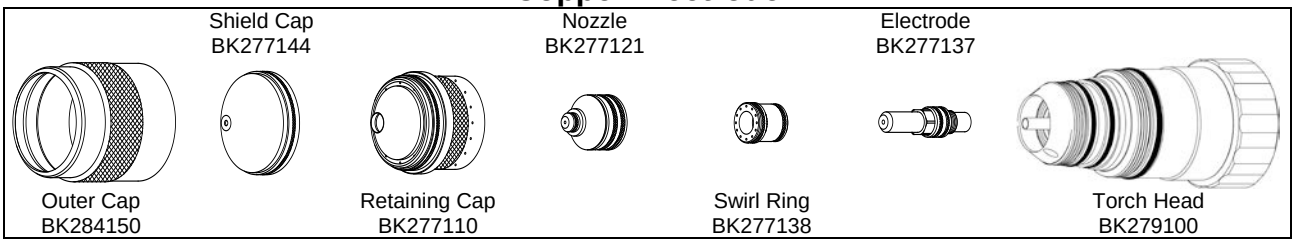
Stainless Steel - 30 Amps - Air Plasma / Air Shield
Copper Electrode



Imperial*

Material Thickness (ga)	Material Thickness (in)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (ipm)	Cutting Height (in)	Pierce Height (in)	Pierce Time (msec)	Kerf Width (in)
20	.036	35	81	30	85	71	200	.020	.050	100	.065
18	.048						165	.035			
16	.060					74	125			200	.068
14	.075					75	90	.025			.070

Metric*

Material Thickness (mm)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (mm/m)	Cutting Height (mm)	Pierce Height (mm)	Pierce Time (msec)	Kerf Width (mm)
1	35	81	30	85	71	4855	0.6	1.3	100	1.7
1.5					73	3260	0.9		200	

Marking* – For All Material Thicknesses

Type of Gas (Plasma)	Type of Gas (Shield)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (ipm)	Travel Speed (mm/min)	Marking Height (in)	Marking Height (mm)	Initial Height (in)	Initial Height (mm)	Pierce Time (msec)
Nitrogen	Nitrogen	N/A	25	25	N/A	145	250	6350	.177	4.5	.100	2.5	0
Argon**	Nitrogen**	N/A	50	25	N/A	55	100	2540	.140	3.6	.100	2.5	0

* Use an arc transfer height (ignition height) of .050" (1.3 mm) for cutting and .100" (2.5 mm) for marking.
** Only available on systems with the Automatic Gas Console.
(Revised 04/26/2013)

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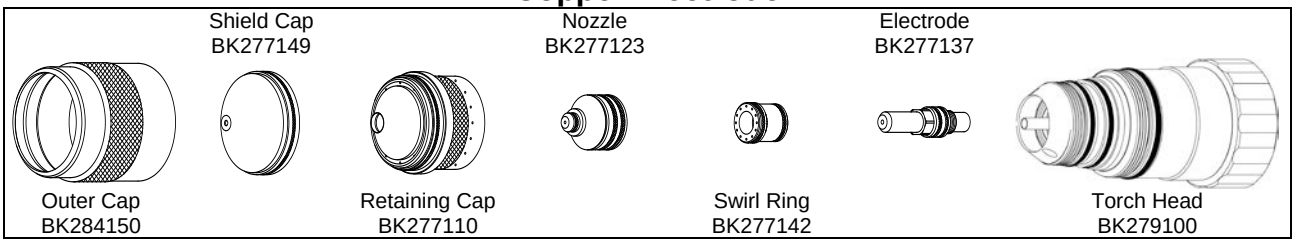
Stainless Steel - 50 Amps - Air Plasma / Nitrogen Shield
Copper Electrode



Imperial*

Material Thickness (ga)	Material Thickness (in)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (ipm)	Cutting Height (in)	Pierce Height (in)	Pierce Time (msec)	Kerf Width (in)
14	.075	25	66	40	67	87	105	.035	.070	100	.105
12	.105					88	75				
11	.120					89	65			200	
10	.135					90	55				.110
	3/16					94	50	.040	.080	300	
	1/4					100	40	.060	.125	400	.115

Metric*

Material Thickness (mm)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (mm/m)	Cutting Height (mm)	Pierce Height (mm)	Pierce Time (msec)	Kerf Width (mm)
2	25	66	40	67	87	2565	.9	1.8	100	2.7
2.5						2080				
3					88	1685			200	
5					94	1235	1.0	2.1	400	2.8
6					98	1075	1.3	2.9		2.9

Marking* – For All Material Thicknesses

Type of Gas (Plasma)	Type of Gas (Shield)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (ipm)	Travel Speed (mm/min)	Marking Height (in)	Marking Height (mm)	Initial Height (in)	Initial Height (mm)	Pierce Time (msec)
Nitrogen	Nitrogen	N/A	25	25	N/A	145	250	6350	.147	3.7	.100	2.5	0
Argon**	Nitrogen**	N/A	50	25	N/A	65	100	2540	.100	2.5	.100	2.5	0

* Use an arc transfer height (ignition height) of .070" (1.8 mm) for cutting and .100" (2.5 mm) for marking.
** Only available on systems with the Automatic Gas Console.
(Revised 04/26/2013)

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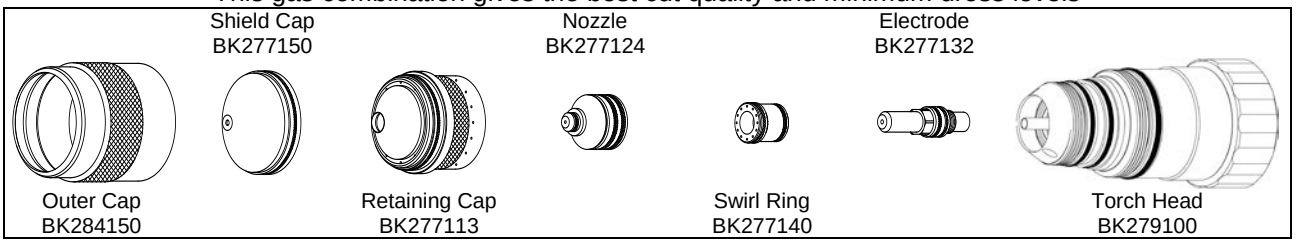
Stainless Steel - 70 Amps - H17 Plasma / Nitrogen Shield
Copper Electrode

(H17 = 17.5% Hydrogen / 32.5% Argon / 50% Nitrogen)

This gas combination gives the best cut quality and minimum dross levels



Imperial*

Material Thickness (in)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (ipm)	Cutting Height (in)	Pierce Height (in)	Pierce Time (msec)	Kerf Width (in)
3/16	35	65	30	60	135	80	.100	.200	300	.090

Metric*

Material Thickness (mm)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (mm/m)	Cutting Height (mm)	Pierce Height (mm)	Pierce Time (msec)	Kerf Width (mm)
5	35	65	30	60	135	2030	2.5	5.1	300	2.3

Marking* – For All Material Thicknesses

Type of Gas (Plasma)	Type of Gas (Shield)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (ipm)	Travel Speed (mm/min)	Marking Height (in)	Marking Height (mm)	Initial Height (in)	Initial Height (mm)	Pierce Time (msec)
Nitrogen	Nitrogen	N/A	25	25	N/A	135	250	6350	.096	2.4	.100	2.5	0
Argon**	Nitrogen**	N/A	50	25	N/A	80	100	2540	.130	3.3	.100	2.5	0

* Use an arc transfer height (ignition height) of .150" (3.8 mm) for cutting and .100" (2.5 mm) for marking.
** Only available on systems with the Automatic Gas Console.
(Revised 04/26/2013)

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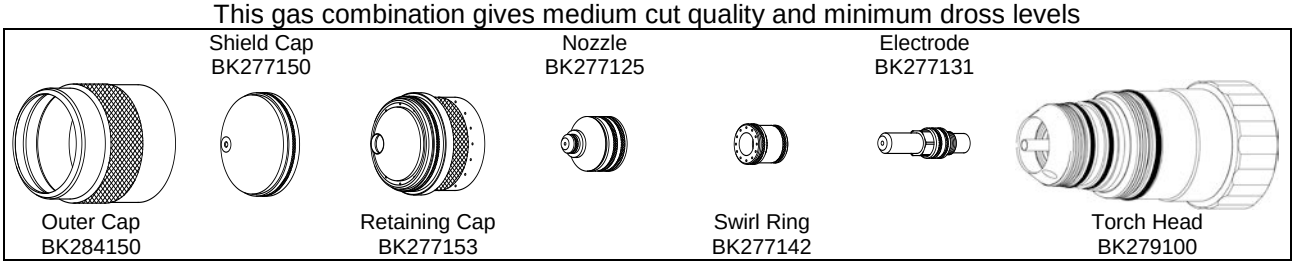
Stainless Steel - 70 Amps - Air Plasma / Nitrogen Shield
Copper Electrode

This gas combination gives medium cut quality and minimum dross levels



Imperial*

Material Thickness (ga)	Material Thickness (in)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (ipm)	Cutting Height (in)	Pierce Height (in)	Pierce Time (msec)	Kerf Width (in)
10	.135	25	76	25	76	132	120	.060	.150	200	.085
	3/16					134	100	.070	.200	300	
	1/4					140	75	.090	.225	400	.090
	3/8					148	50	.120	.250	500	

Metric*

Material Thickness (mm)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (mm/m)	Cutting Height (mm)	Pierce Height (mm)	Pierce Time (msec)	Kerf Width (mm)
3	25	76	25	76	131	3210	1.4	3.3	200	2.2
5					134	2445	1.8	5.1	400	
6					138	2050	2.1	5.5		2.3

Marking* – For All Material Thicknesses

Type of Gas (Plasma)	Type of Gas (Shield)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (ipm)	Travel Speed (mm/min)	Marking Height (in)	Marking Height (mm)	Initial Height (in)	Initial Height (mm)	Pierce Time (msec)
Nitrogen	Nitrogen	N/A	25	25	N/A	135	250	6350	.096	2.4	.100	2.5	0
Argon**	Nitrogen**	N/A	50	25	N/A	65	100	2540	.100	2.5	.100	2.5	0

* Use an arc transfer height (ignition height) of .150" (3.8 mm) for cutting and .100" (2.5 mm) for marking.
** Only available on systems with the Automatic Gas Console.
(Revised 04/26/2013)

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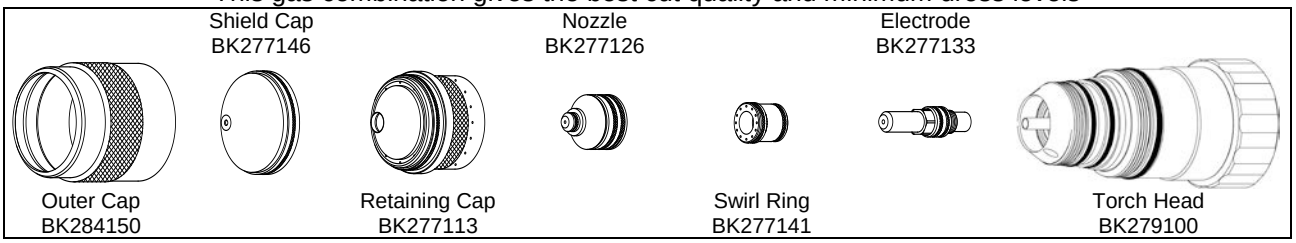
Stainless Steel - 100 Amps - H17 Plasma / Nitrogen Shield
Copper Electrode

(H17 = 17.5% Hydrogen / 32.5% Argon / 50% Nitrogen)

This gas combination gives the best cut quality and minimum dross levels



Imperial*

Material Thickness (in)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (ipm)	Cutting Height (in)	Pierce Height (in)	Pierce Time (msec)	Kerf Width (in)
3/16	28	72	40	67	138	115	.105	.200	300	.100
1/4					140	100	.125	.225	400	.105
3/8					152	65	.180	.250	500	

Metric*

Material Thickness (mm)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (mm/m)	Cutting Height (mm)	Pierce Height (mm)	Pierce Time (msec)	Kerf Width (mm)
5	28	72	40	67	138	2865	2.7	5.1	400	2.5
6					139	2625	3.0	5.5		2.7

Marking* – For All Material Thicknesses

Type of Gas (Plasma)	Type of Gas (Shield)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (ipm)	Travel Speed (mm/min)	Marking Height (in)	Marking Height (mm)	Initial Height (in)	Initial Height (mm)	Pierce Time (msec)
Nitrogen	Nitrogen	N/A	25	25	N/A	130	250	6350	.100	2.5	.100	2.5	0
Argon**	Nitrogen**	N/A	50	25	N/A	80	100	2540	.110	2.8	.100	2.5	0

* Use an arc transfer height (ignition height) of .200" (5.1 mm) for cutting and .100" (2.5 mm) for marking.
** Only available on systems with the Automatic Gas Console.
(Revised 04/26/2013)

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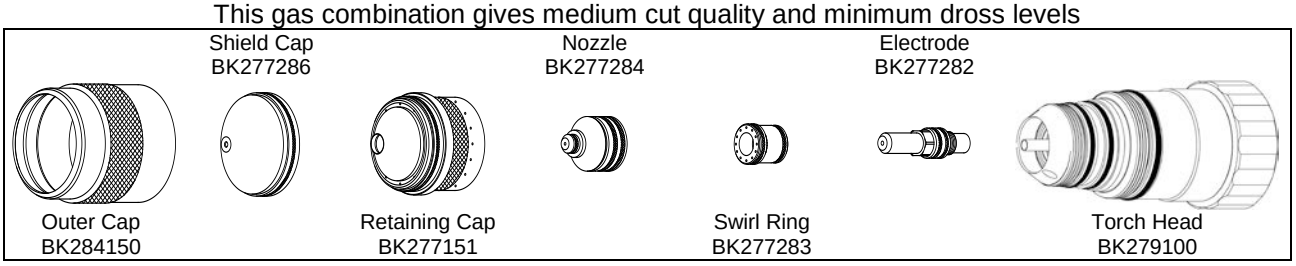
Stainless Steel - 100 Amps - Air Plasma / Nitrogen Shield
Copper Electrode

This gas combination gives medium cut quality and minimum dross levels



Imperial*

Material Thickness (in)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (ipm)	Cutting Height (in)	Pierce Height (in)	Pierce Time (msec)	Kerf Width (in)
1/4	25	80	35	80	141	100	.135	.225	400	.092
3/8					147	80	.170	.250	500	.095
1/2					154	55	.210	.300	600	

Metric*

Material Thickness (mm)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (mm/m)	Cutting Height (mm)	Pierce Height (mm)	Pierce Time (msec)	Kerf Width (mm)
6	25	80	35	80	140	2595	3.2	5.6	400	2.3
10					148	1935	4.4	6.5	600	2.4
12					152	1540	5.0	7.3		

Marking* – For All Material Thicknesses

Type of Gas (Plasma)	Type of Gas (Shield)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (ipm)	Travel Speed (mm/min)	Marking Height (in)	Marking Height (mm)	Initial Height (in)	Initial Height (mm)	Pierce Time (msec)
Nitrogen	Nitrogen	N/A	25	25	N/A	130	250	6350	.100	2.5	.100	2.5	0
Argon**	Nitrogen**	N/A	50	25	N/A	68	100	2540	.100	2.5	.100	2.5	0

* Use an arc transfer height (ignition height) of .200" (5.1 mm) for cutting and .100" (2.5 mm) for marking.
** Only available on systems with the Automatic Gas Console.
(Revised 04/26/2013)

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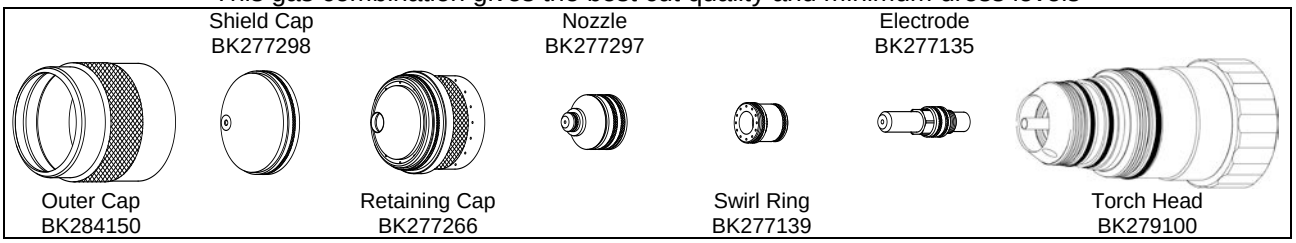
Stainless Steel - 150 Amps - H17 Plasma / Nitrogen Shield
Copper Electrode

(H17 = 17.5% Hydrogen / 32.5% Argon / 50% Nitrogen)

This gas combination gives the best cut quality and minimum dross levels



Imperial*

Material Thickness (in)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (ipm)	Cutting Height (in)	Pierce Height (in)	Pierce Time (msec)	Kerf Width (in)
1/4	25	77	75	81	165	95	.250	.250	400	.135
3/8						75	.150	.275	500	
1/2						60	.165	.300	600	.140
5/8						50	.185	.325	800	
3/4						40	.250	.350	1200	.145

Metric*

Material Thickness (mm)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (mm/m)	Cutting Height (mm)	Pierce Height (mm)	Pierce Time (msec)	Kerf Width (mm)
10	25	77	75	81	155	1845	3.8	7.0	600	3.4
12						1610	4.1	7.4		3.6
16						1260	4.7	8.3	800	
20					167	940	6.9	9.0	1200	3.7

Marking* – For All Material Thicknesses

Type of Gas (Plasma)	Type of Gas (Shield)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (ipm)	Travel Speed (mm/min)	Marking Height (in)	Marking Height (mm)	Initial Height (in)	Initial Height (mm)	Pierce Time (msec)
Nitrogen	Nitrogen	N/A	25	25	N/A	135	250	6350	.100	2.5	.100	2.5	0
Argon**	Nitrogen**	N/A	50	25	N/A	81	100	2540	.140	3.6	.100	2.5	0

* Use an arc transfer height (ignition height) of .200" (5.1 mm) for cutting and .100" (2.5 mm) for marking.
** Only available on systems with the Automatic Gas Console.
(Revised 04/26/2013)

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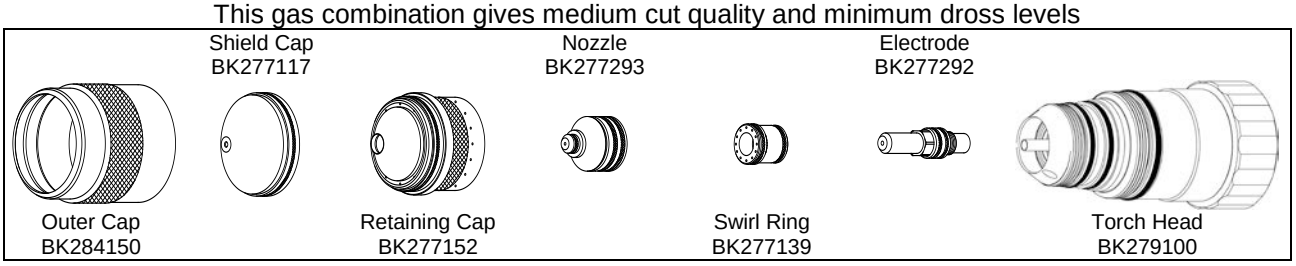
Stainless Steel - 150 Amps - Air Plasma / Nitrogen Shield
Copper Electrode

This gas combination gives medium cut quality and minimum dross levels



Imperial*

Material Thickness (in)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (ipm)	Cutting Height (in)	Pierce Height (in)	Pierce Time (msec)	Kerf Width (in)
1/4	20	71	70	69	145	150	.160	.250	400	.125
3/8					150	115	.180	.275	500	
1/2					155	85	.210	.300	600	.130
5/8					160	60	.220	.325	800	
3/4					168	45	.240	.350	1200	.135

Metric*

Material Thickness (mm)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (mm/m)	Cutting Height (mm)	Pierce Height (mm)	Pierce Time (msec)	Kerf Width (mm)
6	20	71	70	69	144	3910	4.0	6.3	400	3.2
10					150	2805	4.7	7.0	600	
12					153	2330	5.1	7.4		3.3
16					160	1510	5.6	8.3	800	
20					170	1030	6.2	9.0	1200	3.4

Marking* – For All Material Thicknesses

Type of Gas (Plasma)	Type of Gas (Shield)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (ipm)	Travel Speed (mm/min)	Marking Height (in)	Marking Height (mm)	Initial Height (in)	Initial Height (mm)	Pierce Time (msec)
Nitrogen	Nitrogen	N/A	25	25	N/A	135	250	6350	.100	2.5	.100	2.5	0
Argon**	Nitrogen**	N/A	50	25	N/A	65	100	2540	.100	2.5	.100	2.5	0

* Use an arc transfer height (ignition height) of .200" (5.1 mm) for cutting and .100" (2.5 mm) for marking.
** Only available on systems with the Automatic Gas Console.
(Revised 04/26/2013)

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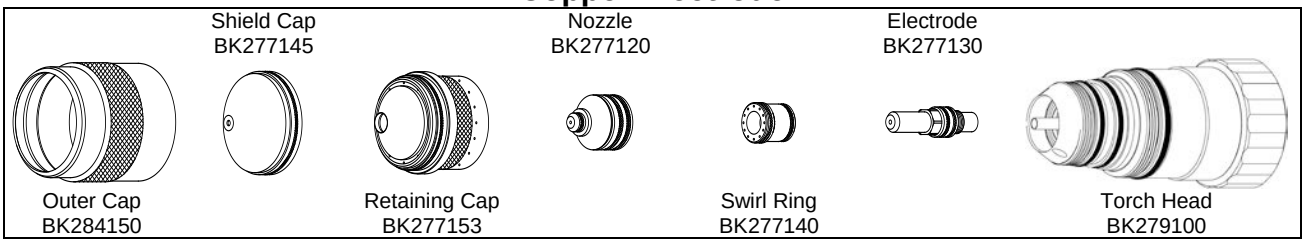
Aluminum - 30 Amps - Air Plasma / Nitrogen Shield
Copper Electrode



Imperial*

Material Thickness (in)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (ipm)	Cutting Height (in)	Pierce Height (in)	Pierce Time (msec)	Kerf Width (in)
.040	35	81	20	85	135	150	.030	.100	100	.065
.050						120				
.063						90		.150	200	.070

Metric*

Material Thickness (mm)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (mm/m)	Cutting Height (mm)	Pierce Height (mm)	Pierce Time (msec)	Kerf Width (mm)
1	35	81	20	85	135	3885	0.8	2.5	100	1.7
1.5						2520		3.4	200	1.8

Marking* – For All Material Thicknesses

Type of Gas (Plasma)	Type of Gas (Shield)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (ipm)	Travel Speed (mm/min)	Marking Height (in)	Marking Height (mm)	Initial Height (in)	Initial Height (mm)	Pierce Time (msec)
Nitrogen	Nitrogen	N/A	25	25	N/A	145	250	6350	.177	4.5	.100	2.5	0
Argon**	Air**	N/A	50	25	N/A	75	100	2540	.120	3.0	.100	2.5	0

* Use an arc transfer height (ignition height) of .100" (2.5 mm) for cutting and .100" (2.5 mm) for marking.
** Only available on systems with the Automatic Gas Console.
(Revised 04/26/2013)

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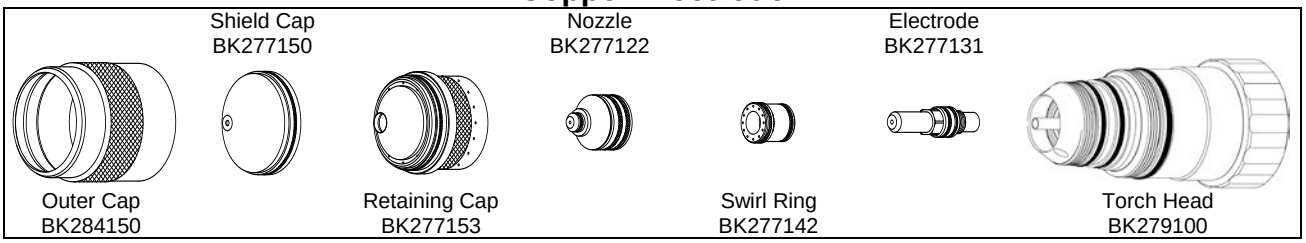
Aluminum - 50 Amps - Air Plasma / Nitrogen Shield
Copper Electrode



Imperial*

Material Thickness (in)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (ipm)	Cutting Height (in)	Pierce Height (in)	Pierce Time (msec)	Kerf Width (in)
.050	25	66	19	67	135	180	.050	.100	100	.080
.063					138	140	.065		150	.082
.080					143	90	.075	.150	200	.085

Metric*

Material Thickness (mm)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (mm/m)	Cutting Height (mm)	Pierce Height (mm)	Pierce Time (msec)	Kerf Width (mm)
1.5	25	66	19	67	137	3870	1.5	2.5	150	2.1
2.0					142	2360	1.8	3.7	200	2.2

Marking* – For All Material Thicknesses

Type of Gas		Preflow	Plasma	Shield	Postflow	Arc Voltage	Travel Speed		Marking Height		Initial Height		Pierce Time
(Plasma)	(Shield)	(psi)	(psi)	(psi)	(psi)	(volts)	(ipm)	(mm/min)	(in)	(mm)	(in)	(mm)	(msec)
Nitrogen	Nitrogen	N/A	25	25	N/A	145	250	6350	.147	3.7	.100	2.5	0
Argon**	Air**	N/A	50	25	N/A	77	100	2540	.120	3.0	.100	2.5	0

* Use an arc transfer height (ignition height) of .100" (2.5 mm) for cutting and .100" (2.5 mm) for marking.
** Only available on systems with the Automatic Gas Console.
(Revised 04/26/2013)

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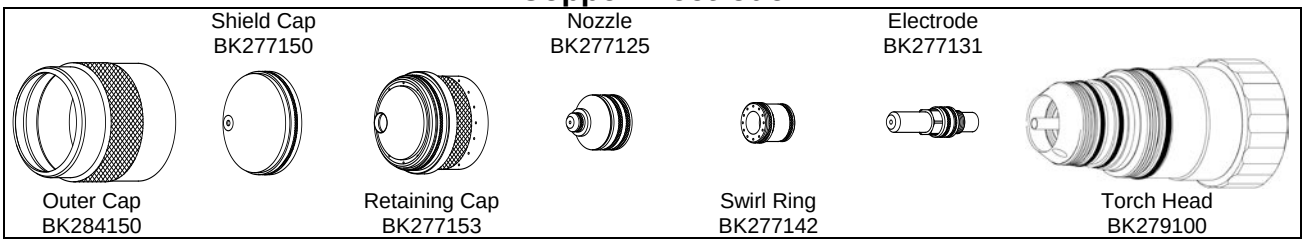
Aluminum - 70 Amps - Air Plasma / Nitrogen Shield
Copper Electrode



Imperial*

Material Thickness (in)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (ipm)	Cutting Height (in)	Pierce Height (in)	Pierce Time (msec)	Kerf Width (in)
.080	25	76	25	76	130	250	.050	.150	100	.080
1/8					135	160	.070	.175		
3/16					145	80	.100	.200	200	.085
1/4					150	50	.060	.250	300	
3/8					155	40	.075	.275	400	.090
1/2					162	30	.115	.300	500	

Metric*

Material Thickness (mm)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (mm/m)	Cutting Height (mm)	Pierce Height (mm)	Pierce Time (msec)	Kerf Width (mm)
2	25	76	25	76	129	6400	1.2	3.7	100	2.0
3					134	4420	1.7	4.3		
5					145	1920	2.3	5.2	300	2.2
6					148	1440	1.7	6.1		
10					156	975	2.0	7.0	500	2.3
12					160	820	2.6	7.4		

Marking* – For All Material Thicknesses

Type of Gas		Preflow	Plasma	Shield	Postflow	Arc Voltage	Travel Speed		Marking Height		Initial Height		Pierce Time
(Plasma)	(Shield)	(psi)	(psi)	(psi)	(psi)	(volts)	(ipm)	(mm/min)	(in)	(mm)	(in)	(mm)	(msec)
Nitrogen	Nitrogen	N/A	25	25	N/A	135	250	6350	.096	2.4	.100	2.5	0
Argon**	Air**	N/A	50	25	N/A	69	100	2540	.120	3.0	.100	2.5	0

* Use an arc transfer height (ignition height) of .150" (3.8 mm) for cutting and .100" (2.5 mm) for marking.
** Only available on systems with the Automatic Gas Console.
(Revised 04/26/2013)

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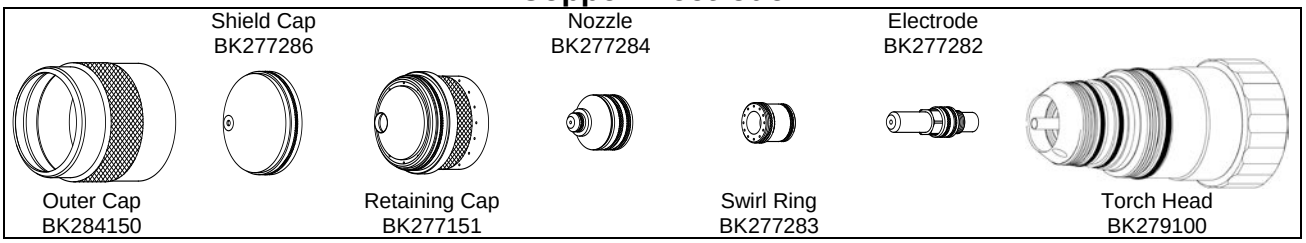
Aluminum - 100 Amps - Air Plasma / Nitrogen Shield
Copper Electrode



Imperial*

Material Thickness (in)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (ipm)	Cutting Height (in)	Pierce Height (in)	Pierce Time (msec)	Kerf Width (in)
1/4	25	80	26	80	158	105	.155	.250	300	.095
3/8					162	90	.180	.275	400	.098
1/2					165	70	.195	.300	500	.100

Metric*

Material Thickness (mm)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (mm/m)	Cutting Height (mm)	Pierce Height (mm)	Pierce Time (msec)	Kerf Width (mm)
6	25	80	26	80	158	2710	3.8	6.3	300	2.4
10					162	2210	4.6	7.0	500	2.5
12					165	1890	4.9	7.4		

Marking* – For All Material Thicknesses

Type of Gas (Plasma)	Type of Gas (Shield)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (ipm)	Travel Speed (mm/min)	Marking Height (in)	Marking Height (mm)	Initial Height (in)	Initial Height (mm)	Pierce Time (msec)
Nitrogen	Nitrogen	N/A	25	25	N/A	130	250	6350	.100	2.5	.100	2.5	0
Argon**	Air**	N/A	50	25	N/A	71	100	2540	.120	3.0	.100	2.5	0

* Use an arc transfer height (ignition height) of .250" (6.4 mm) for cutting and .100" (2.5 mm) for marking.
** Only available on systems with the Automatic Gas Console.
(Revised 04/26/2013)

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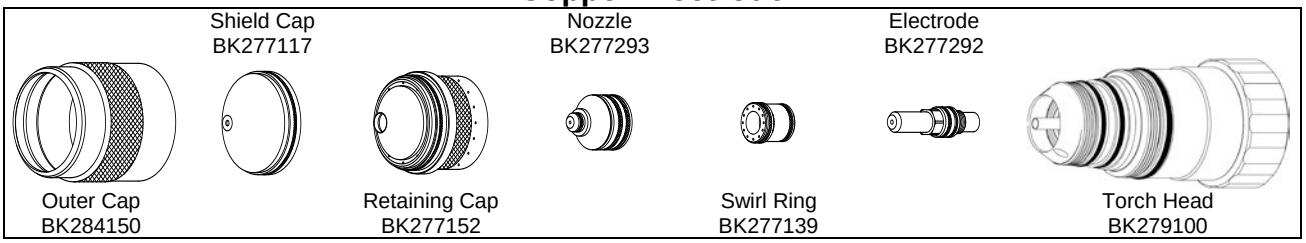
Aluminum - 150 Amps - Air Plasma / Nitrogen Shield
Copper Electrode



Imperial*

Material Thickness (in)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (ipm)	Cutting Height (in)	Pierce Height (in)	Pierce Time (msec)	Kerf Width (in)
1/4	20	71	50	69	145	145	.130	.250	400	.125
3/8					155	115	.185	.275	500	
1/2					165	90	.230	.300	600	.130
5/8					170	65	.250	.325	800	.135
3/4						45		.350	1200	.140

Metric*

Material Thickness (mm)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (mm/m)	Cutting Height (mm)	Pierce Height (mm)	Pierce Time (msec)	Kerf Width (mm)
6	20	71	50	69	143	3770	3.1	6.3	400	3.2
10					156	2825	4.8	7.0	600	
12					162	2430	5.5	7.4		3.3
16					170	1630	6.4	8.3	1200	3.4
20					170	990		9.0		3.6

Marking* – For All Material Thicknesses

Type of Gas (Plasma)	Type of Gas (Shield)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (ipm)	Travel Speed (mm/min)	Marking Height (in)	Marking Height (mm)	Initial Height (in)	Initial Height (mm)	Pierce Time (msec)
Nitrogen	Nitrogen	N/A	25	25	N/A	135	250	6350	.100	2.5	.100	2.5	0
Argon**	Air**	N/A	50	25	N/A	69	100	2540	.100	2.5	.100	2.5	0

* Use an arc transfer height (ignition height) of .250" (6.4 mm) for cutting and .100" (2.5 mm) for marking.
** Only available on systems with the Automatic Gas Console.
(Revised 04/26/2013)

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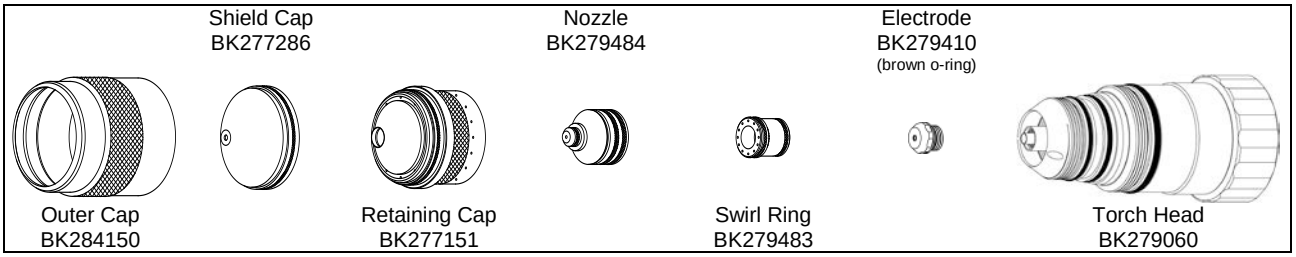
Mild Steel - 100 Amps - Oxygen Plasma / Air Shield
Silver Electrode



Imperial*

Material Thickness (in)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (ipm)	Cutting Height (in)	Pierce Height (in)	Pierce Time (msec)	Kerf Width (in)
1/4	25	83	26	81	125	150	.090	.200	300	.090
3/8					130	100	.130	.250	400	
1/2						65	.155	.300	500	
5/8					143	47	.185	.325	800	.095
3/4					145	35		.350	1000	

Metric*

Material Thickness (mm)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (mm/m)	Cutting Height (mm)	Pierce Height (mm)	Pierce Time (msec)	Kerf Width (mm)
6	25	83	26	81	124	3950	2.1	4.9	300	2.3
10					130	2405	3.3	6.5	500	
12						1850	3.7	7.3		
16					143	1180	4.7	8.3	1000	2.4
20					145	800		9.0		

Marking* – For All Material Thicknesses

Type of Gas (Plasma)	Type of Gas (Shield)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (ipm)	Travel Speed (mm/min)	Marking Height (in)	Marking Height (mm)	Initial Height (in)	Initial Height (mm)	Pierce Time (msec)
Nitrogen	Nitrogen	N/A	25	25	N/A	130	250	6350	.100	2.5	.100	2.5	0
Argon**	Air**	N/A	50	25	N/A	60	100	2540	.100	2.5	.100	2.5	0

* Use an arc transfer height (ignition height) of .200" (5.1 mm) for cutting and .100" (2.5 mm) for marking.
** Only available on systems with the Automatic Gas Console.
(Revised 04/26/2013)

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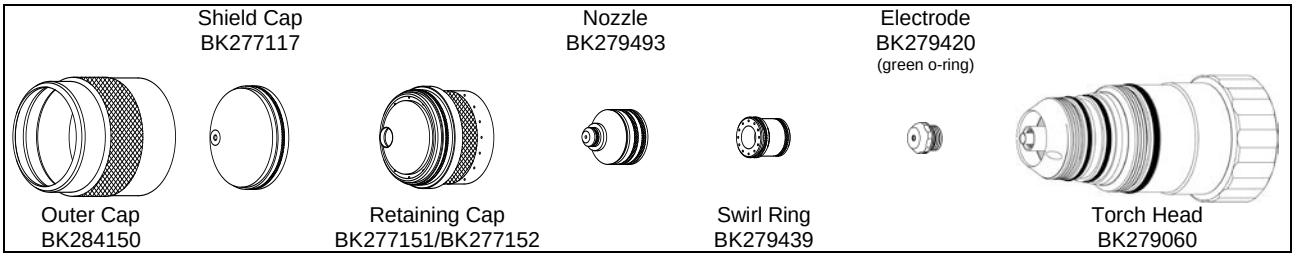
Mild Steel - 150 Amps - Oxygen Plasma / Air Shield
Silver Electrode



Imperial*

Material Thickness (in)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (ipm)	Cutting Height (in)	Pierce Height (in)	Pierce Time (msec)	Kerf Width (in)
Retaining Cap BK277151										
1/4	20	71	30	69	118	165	.105	.200	300	.125
3/8					123	125	.135	.250	400	
1/2					125	90	.140	.300	500	.130
Retaining Cap BK277152										
5/8	20	71	45	69	127	70	.140	.325	600	.130
3/4					130	55		.350	1000	.135
1					134	40	.150	.400	1500	.140
1.25 ***					145	25	.200	.350		
1.50 ***					155	15	.225	.350		

Metric*

Material Thickness (mm)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (mm/m)	Cutting Height (mm)	Pierce Height (mm)	Pierce Time (msec)	Kerf Width (mm)
Retaining Cap BK277151										
6	20	71	30	69	117	4305	2.6	4.9	300	3.2
10					123	3040	3.4	6.5	500	
12					124	2485	3.5	7.3		3.3
Retaining Cap BK277152										
16	20	71	45	69	127	1760	3.6	8.3	1000	3.3
20					130	1340		9.0	1500	3.4
25					133	1040	3.7	10.1		3.6
32 ***					145	625	5.1	8.9		
38 ***					154	385	5.6	8.9		

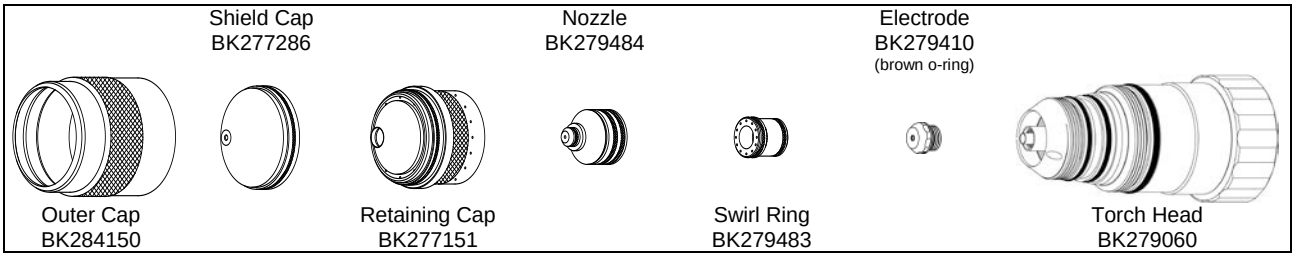
Marking* – For All Material Thicknesses

Type of Gas (Plasma)	Type of Gas (Shield)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (ipm)	Travel Speed (mm/min)	Marking Height (in)	Marking Height (mm)	Initial Height (in)	Initial Height (mm)	Pierce Time (msec)
Nitrogen	Nitrogen	N/A	25	25	N/A	135	250	6350	.100	2.5	.100	2.5	0
Argon**	Air**	N/A	50	25	N/A	61	100	2540	.100	2.5	.100	2.5	0

* Use an arc transfer height (ignition height) of .200" (5.1 mm) for cutting and .100" (2.5 mm) for marking.
** Only available on systems with the Automatic Gas Console.
*** Edge start recommended.
(Revised 04/26/2013)

This information is subject to the controls of the Export Administration Regulations [EAR]. This information shall not be provided to non-U.S. persons or transferred by any means to any location outside the United States contrary to the requirements of the EAR.

Stainless Steel - 100 Amps - Air Plasma / Nitrogen Shield
Silver Electrode



Imperial*

Material Thickness (in)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (ipm)	Cutting Height (in)	Pierce Height (in)	Pierce Time (msec)	Kerf Width (in)
1/4	25	80	35	80	141	100	.135	.225	400	.092
3/8					147	80	.170	.250	500	.095
1/2					154	55	.210	.300	600	

Metric*

Material Thickness (mm)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (mm/m)	Cutting Height (mm)	Pierce Height (mm)	Pierce Time (msec)	Kerf Width (mm)
6	25	80	35	80	140	2595	3.2	5.6	400	2.3
10					148	1935	4.4	6.5	600	2.4
12					152	1540	5.0	7.3		

Marking* – For All Material Thicknesses

Type of Gas (Plasma)	Type of Gas (Shield)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (ipm)	Travel Speed (mm/min)	Marking Height (in)	Marking Height (mm)	Initial Height (in)	Initial Height (mm)	Pierce Time (msec)
Nitrogen	Nitrogen	N/A	25	25	N/A	130	250	6350	.100	2.5	.100	2.5	0
Argon**	Nitrogen**	N/A	50	25	N/A	68	100	2540	.100	2.5	.100	2.5	0

* Use an arc transfer height (ignition height) of .200" (5.1 mm) for cutting and .100" (2.5 mm) for marking.
** Only available on systems with the Automatic Gas Console.
(Revised 04/26/2013)

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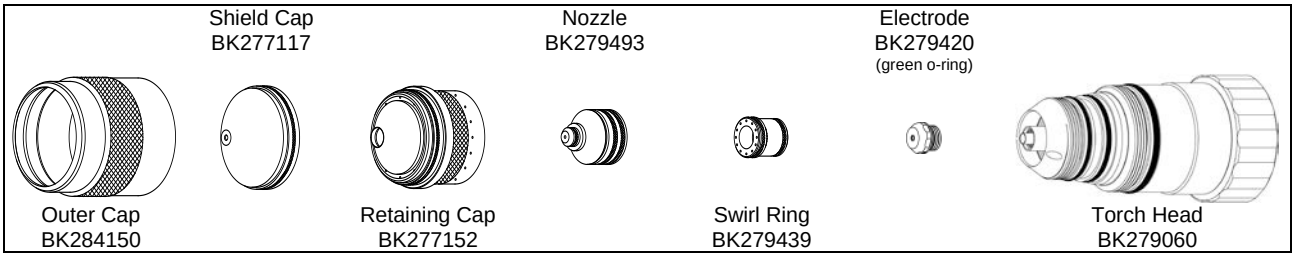
Stainless Steel - 150 Amps - Air Plasma / Nitrogen Shield
Silver Electrode



Imperial*

Material Thickness (in)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (ipm)	Cutting Height (in)	Pierce Height (in)	Pierce Time (msec)	Kerf Width (in)
1/4	20	71	70	69	145	150	.160	.250	400	.125
3/8					150	115	.180	.275	500	
1/2					155	85	.210	.300	600	.130
5/8					160	60	.220	.325	800	
3/4					168	45	.240	.350	1200	.135

Metric*

Material Thickness (mm)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (mm/m)	Cutting Height (mm)	Pierce Height (mm)	Pierce Time (msec)	Kerf Width (mm)
6	20	71	70	69	144	3910	4.0	6.3	400	3.2
10					150	2805	4.7	7.0	600	
12					153	2330	5.1	7.4		3.3
16					160	1510	5.6	8.3	800	
20					170	1030	6.2	9.0	1200	3.4

Marking* – For All Material Thicknesses

Type of Gas (Plasma)	Type of Gas (Shield)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (ipm)	Travel Speed (mm/min)	Marking Height (in)	Marking Height (mm)	Initial Height (in)	Initial Height (mm)	Pierce Time (msec)
Nitrogen	Nitrogen	N/A	25	25	N/A	135	250	6350	.100	2.5	.100	2.5	0
Argon**	Nitrogen**	N/A	50	25	N/A	65	100	2540	.100	2.5	.100	2.5	0

* Use an arc transfer height (ignition height) of .200" (5.1 mm) for cutting and .100" (2.5 mm) for marking.
** Only available on systems with the Automatic Gas Console.
(Revised 04/26/2013)

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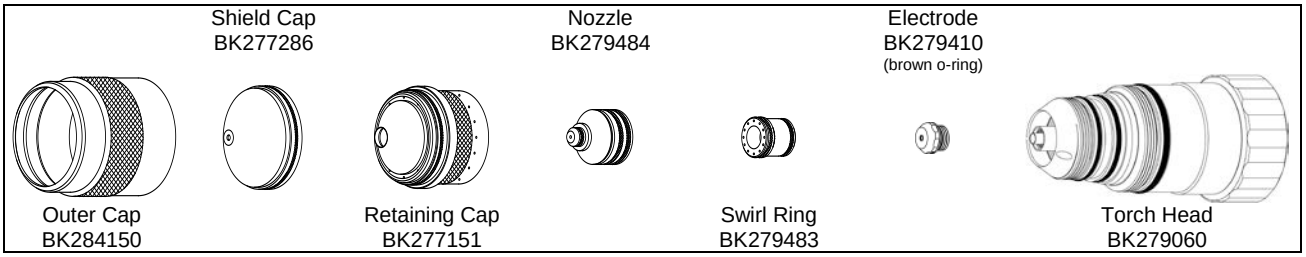
Aluminum - 100 Amps - Air Plasma / Nitrogen Shield
Silver Electrode



Imperial*

Material Thickness (in)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (ipm)	Cutting Height (in)	Pierce Height (in)	Pierce Time (msec)	Kerf Width (in)
1/4	25	80	26	80	158	105	.155	.250	300	.095
3/8					162	90	.180	.275	400	.098
1/2					165	70	.195	.300	500	.100

Metric*

Material Thickness (mm)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (mm/m)	Cutting Height (mm)	Pierce Height (mm)	Pierce Time (msec)	Kerf Width (mm)
6	25	80	26	80	158	2710	3.8	6.3	300	2.4
10					162	2210	4.6	7.0	500	2.5
12					165	1890	4.9	7.4		

Marking* – For All Material Thicknesses

Type of Gas (Plasma)	Type of Gas (Shield)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (ipm)	Travel Speed (mm/min)	Marking Height (in)	Marking Height (mm)	Initial Height (in)	Initial Height (mm)	Pierce Time (msec)
Nitrogen	Nitrogen	N/A	25	25	N/A	130	250	6350	.100	2.5	.100	2.5	0
Argon**	Air**	N/A	50	25	N/A	71	100	2540	.120	3.0	.100	2.5	0

* Use an arc transfer height (ignition height) of .250" (6.4 mm) for cutting and .100" (2.5 mm) for marking.
** Only available on systems with the Automatic Gas Console.
(Revised 04/26/2013)

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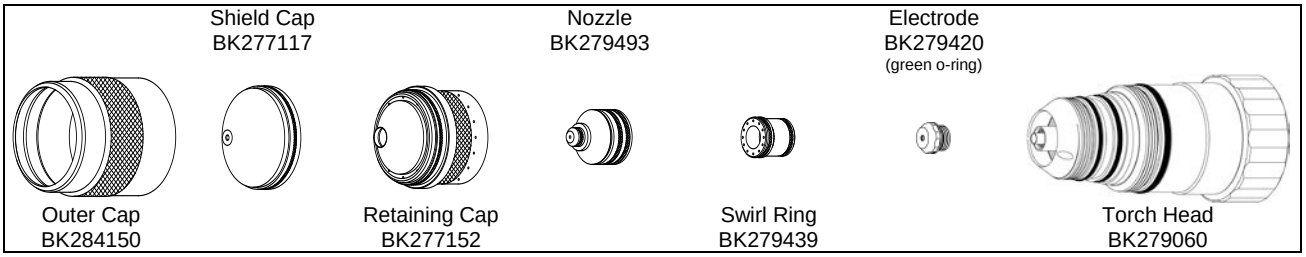
Aluminum - 150 Amps - Air Plasma / Nitrogen Shield
Silver Electrode



Imperial*

Material Thickness (in)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (ipm)	Cutting Height (in)	Pierce Height (in)	Pierce Time (msec)	Kerf Width (in)
1/4	20	71	50	69	145	145	.130	.250	400	.125
3/8					155	115	.185	.275	500	
1/2					165	90	.230	.300	600	.130
5/8					170	65	.250	.325	800	.135
3/4						45		.350	1200	.140

Metric*

Material Thickness (mm)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (mm/m)	Cutting Height (mm)	Pierce Height (mm)	Pierce Time (msec)	Kerf Width (mm)
6	20	71	50	69	143	3770	3.1	6.3	400	3.2
10					156	2825	4.8	7.0	600	
12					162	2430	5.5	7.4		3.3
16					170	1630	6.4	8.3	1200	3.4
20					170	990		9.0		3.6

Marking* – For All Material Thicknesses

Type of Gas (Plasma)	Type of Gas (Shield)	Preflow (psi)	Plasma (psi)	Shield (psi)	Postflow (psi)	Arc Voltage (volts)	Travel Speed (ipm)	Travel Speed (mm/min)	Marking Height (in)	Marking Height (mm)	Initial Height (in)	Initial Height (mm)	Pierce Time (msec)
Nitrogen	Nitrogen	N/A	25	25	N/A	135	250	6350	.100	2.5	.100	2.5	0
Argon**	Air**	N/A	50	25	N/A	69	100	2540	.100	2.5	.100	2.5	0

* Use an arc transfer height (ignition height) of .250" (6.4 mm) for cutting and .100" (2.5 mm) for marking.
** Only available on systems with the Automatic Gas Console.
(Revised 04/26/2013)

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Section 6: Maintenance & Troubleshooting

WARNING: Only qualified maintenance personnel should perform maintenance on the Spirit system.

The system utilizes potentially fatal A.C. and D.C. voltages. All maintenance should be performed with safety in mind.

Use extreme caution when working near the power conversion module (i.e., chopper). The large electrolytic capacitors store large amounts of energy even after power has been removed from the system. Wait at least five minutes after turning off power, and then use a voltmeter to verify that the capacitors are fully discharged before touching the power conversion module.

Capacitor failure can injure and/or cause property damage.

If troubleshooting requires the system to be powered with the enclosure panels removed, remain clear of the capacitors. Failure of a capacitor can result in a sudden release of stored energy causing rupture of the capacitor case.

Routine Maintenance

Note: At minimum, these checks should be performed on a monthly basis. In excessively dirty environments or in heavy usage situations, the checks should be performed more frequently.

Power Supply

1. Remove the left, right, and top covers on the power supply.
2. Using clean, dry, compressed air, blow out all accumulated dust, including dust on PC boards and fans. Be sure to blow out the fan and heat exchanger at the rear of the unit. In an excessively dirty environment, blow out the unit on a weekly basis.
3. Verify the ground and primary three phase A.C. voltage connections are tight.
4. Verify all PC board connectors are installed securely.
5. Verify all rear cable connectors are installed securely.
6. Verify the electrode lead and work ground lead are secure and free from corrosion.
7. Check the torch coolant filter / deionization cartridge at the rear of the power supply and replace if dirty.
8. Flush the cooling system every six months and replace the coolant and coolant filter / deionization cartridge.

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Manual Gas Console (MGC)

1. Remove the cover of the manual gas console. Using clean, dry, compressed air, blow out all accumulated dust inside the unit. In an excessively dirty environment, blow out the unit on a weekly basis.
2. Verify that all PC board connectors are installed securely.
3. Verify that all gas hose connectors are tight and that there are no leaks. **Only tighten the gas fittings enough to make a gas seal. The fittings are subject to damage if over tightened**.
4. Inspect all gas hoses to ensure no damage exists. Immediately replace any damaged gas hoses.

Torch, Torch Leads, and Gas Hoses

1. Verify that all torch lead and gas hose connections are tight and that there are no gas or water leaks. **Only tighten the fittings enough to make a water or gas seal. The fittings are subject to damage if over tightened**.
2. Verify that the braided shield of the torch leads is fastened securely to the brass shield adapter that connects to the impulse start console. Also, make sure the shield adapter is secured tightly to the impulse start console enclosure.
3. Inspect the braided shield for nicks or cuts and replace if necessary.
4. Remove the torch handle and verify that the connections at the torch base are tightened securely. **Only tighten the fittings enough to make a water or gas seal. The fittings are subject to damage if over tightened**. Coolant leaking from the drain hole in the torch handle indicates damaged or loose torch leads.
5. Make sure the torch lead insulating sleeves are positioned to properly cover the brass torch fittings at the torch base.
6. Inspect the outer sleeve on the torch base's electrode/coolant supply lead. If nicks, cuts or holes are found, replace the torch base.
7. Remove the torch consumables from the torch head and inspect all o-rings. Replace any o-rings with cuts, nicks, abrasions, or any other signs of wear. Faulty o-rings may cause gas or water leaks, which will affect cut quality.
8. With the electrode removed, inspect the cooling tube in the torch head for damage.

   If using the copper electrode, the torch head uses cooling tube P/N BK277007. If replacement is required, use tool P/N BK200109.

   If using the silver electrode, the torch head uses cooling tube holder assembly P/N BK279216. Remove this using the tool (socket P/N BK277087 & driver P/N BK277086) and inspect the o-rings for damage. Apply a small amount of o-ring lubricant before re-installing in the torch head.
9. Wipe any excess o-ring lubricant off of the torch base and head.

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Impulse Start Console (ISC)

1. Open the cover (door) of the impulse start console and verify that all leads and hoses are tightened securely. **Only tighten the fittings enough to make a water or gas seal. The fittings are subject to damage if over tightened**.

Work Ground

1. Verify that the work ground lead is securely fastened to the star ground on the cutting table, and that the connection point is free from corrosion. Use a wire brush to clean the connection point if necessary.

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Replacing the Torch Coolant and Filter

⚠ ***WARNING: Do not touch the fans inside the power supply.***

Important: Never turn on the system when the coolant reservoir is empty.
Important: When handling coolant, wear nitrile gloves and safety glasses.
Important: Only use Kaliburn approved coolant. Commercially available antifreeze contains corrosion inhibitors that will damage the cooling system. See Section 2 for more information.

The torch coolant should be flushed out of the system every six months and replaced with new coolant. Replace the coolant filter / deionization cartridge at the same time.

1. Remove primary power from the Spirit system.
2. Ensure the torch base and torch head (with consumables) are properly installed.
3. Ensure the coolant supply (in and out) hoses are properly installed.
4. Remove the coolant reservoir cap/level gauge.
5. Remove the top, left and right covers from the power supply.
6. Connect a 3/8" ID hose and bucket to the drain petcock on the bottom of the reservoir. Unscrew the petcock to drain the reservoir. Leave the hose and bucket in place after the coolant drains out.
7. Remove the coolant supply hose (coolant out) from the rear of the power supply. Note that the coolant supply hose has right hand threads. Be prepared for some coolant to escape from the fitting on the power supply and from the supply hose.
8. Blow compressed air (100 psi maximum) into the coolant supply hose. This will force the remaining coolant from the torch, torch leads, and supply hose into the reservoir and out of the drain petcock. Continue until coolant stops flowing into the bucket.
9. Tighten the drain petcock and remove the hose and bucket.
10. Protect the area beneath the coolant filter housing as coolant will leak during this step. Unscrew the coolant filter housing and remove it from the power supply. Use caution as the housing will be full of coolant. Install a new coolant filter / deionization cartridge and replace the coolant filter housing. Remove the protective material and dry any leaked coolant.
11. Reconnect the coolant supply hose on the rear of the power supply.
12. Follow all of the steps in "Filling the Cooling System" in Section 3 of this manual to complete this procedure.

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Microprocessor (DSP) Status Indicators

The microprocessor DSP board controls all of the functions of the Spirit power supply. It contains diagnostic LEDs and OPTO LEDs which aid in troubleshooting the system. These indicators illuminate when a particular event occurs. Illuminated LEDs indicate the following:

LED	Indication
D7 – RS232 OUT Isolated	Serial transmission
D10 – RS232 T1 OUT	Serial transmission
D11 – CAN RXD	CAN transmission
D12 – CAN TXD	CAN transmission
D24 – PWM	Chopper(s) energized
D33 – COOLANT LEVEL	Coolant reservoir level is sufficient
D36 – PLASMA START	Plasma start signal applied to Spirit
D37 – ARC HOLD	Arc hold input enabled
D38 – MARKING	Marking input enabled
D39 – CORNER	Corner current input enabled
D40 – EOFF	Off button disengaged
D41 – MOTION	Motion output signal activated
D42 – PLASMA READY	Power supply ready output signal activated
D43 – PAT	Pilot arc transistor energized
D48 – RMT ON/OFF	Remote On/Off input enabled
D50 – ISC DOOR	ISC door is closed
D77 – 3.3V uP PWR	3.3V Microprocessor power
D78 – 1.8V uP PWR	1.8V Microprocessor power
OPTO U21 – MTR/SOL	Coolant pump relay CR5 energized (Pump On)
OPTO U22 – PAR	Pilot arc relay energized
OPTO U23 – CON	DC power output (main contactor energized)
OPTO U24 – SURGE	CR3 and K1 (I/O PCB) relays energized
OPTO U26 – FAN	Fans energized
OPTO U27 – PREFLOW	Preflow gas valve 1 energized
OPTO U28 – PLASMA	Plasma gas valve 2 energized
OPTO U29 – SHIELD	Shield gas valve 3 energized
OPTO U30 – VENT	Vent gas valve 4 energized
OPTO U31 – POSTFLOW	Postflow gas valve 5 energized
OPTO U32 – MARKING	Marking gas valves 6 and 7 energized
OPTO U34 – IMPULSE START	Impulse start circuit energized
OPTO U37 – RHF	HF transformer energized

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Microprocessor (DSP) Sequence of Operation

The following DSP Indicators should illuminate after primary power is applied:

- D77 3.3V Supply
- D78 1.8V Supply
- D50 ISC (Door)
- D33 Coolant Level
- D37 Arc Hold (if INOVA is being used)
- D10 RS232 T1 Out (Blinking)
- D11 CAN RXD (Dim Flashing)
- D12 CAN TXD (Dim Flashing)

The following DSP Indicators should illuminate when the OFF Button is released:

- D40 OFF Button

The following DSP Indicators should illuminate when the ON Button is activated:

- U21 Opto Motor / Solenoid
- U19 Opto Solenoid (not used)
- U26 Opto Fan
- D42 Plasma Ready

The following DSP Indicators should illuminate when a START signal is applied (begin cut cycle):

- D36 Start
- U27 Opto Preflow
- U29 Opto Shield
- U24 Opto Surge (only over 100 amps)
- U23 Opto Contactor
- D24 PWM (Chopper ON)
- U22 Opto Pilot Arc Relay ON
- D43 PAT ON (Blinks during a START)
- U34 Opto ISC (Blinks during a START)

The following DSP Indicators should illuminate with an arc transfer:

- U31 Opto Postflow
- U28 Opto Plasma
- D41 Motion

The following LEDs should turn OFF after the Motion Indicator turns ON:

- U34 Opto ISC
- U27 Opto Preflow
- D43 PAT

When the START signal is removed, OPTO U30 (Vent) will illuminate. It will then go out with the rest of the cut cycle indicators.

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Error Codes

The following is a comprehensive list of error codes for the Spirit system. When the system uses a Manual Gas Console, only the numeric error code is displayed. When an Automatic Gas Console is used, the text description is also displayed.

Power Supply		
Code	**Short Description**	**Long Description**
10121	ISC Door	ISC Door is open
10138	Stop Pressed (Off Button)	OFF Button on Plasma Console or Manual Gas Console is pressed.
10140	Phase R	Transformer Secondary phase voltage is low
10150	Phase Y	Transformer Secondary phase voltage is low
10160	Phase B	Transformer Secondary phase voltage is low
10161	CON1	Main Contactor failed to open
10170	Coolant Level	Coolant Level is low
10180	Coolant Flow Low	Coolant flow is low
10190	Coolant Flow High	Coolant flow is high
10220	Coolant Temperature High	The coolant temperature is high
10290	GC Quiet	Lost CAN communication with Gas Console
10300	PC Quiet	Lost CAN communication with Plasma Console
10320	FCC Invalid	Final Cut Current invalid
10330	PAC Invalid	Pilot Arc Current invalid
10340	AH IHS Timeout	Arc Hold for Initial Height Sense has timed out
10350	PAT Not Established	Pilot Arc Current not established within 2 seconds
10360	TAC Not Established	Transferred Arc Current not established within 2 seconds
10370	Current Unbalanced	Current is not balanced between chopper assemblies (275A and 400A systems)
10380	TAC Lost 1	Transferred Arc lost during TAC hold time
10390	TAC Lost 2	Transferred Arc lost during Upslope
10400	TAC Lost 3	Transferred Arc lost during Cutting
10410	TAC Lost 4	Transferred Arc lost during Downslope
10420	FCC Unreached	Did not achieve final cut current
10430	Output Over Current	Chopper has exceeded its maximum rated current
10432	Output Over Current TZ	Instantaneous Over Current detected
10440	Output Over Voltage	Maximum Cutting Voltage has been exceeded.
10450	Start Premature Removal	Start Signal removed prior to completion of upslope
10461	Chopper1 Temp	Chopper 1 maximum operating temperature exceeded
10462	Chopper2 Temp	Chopper 2 maximum operating temperature exceeded
10463	Chopper3 Temp	Chopper 3 maximum operating temperature exceeded

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Gas Console		
Code	**Short Description**	**Long Description**
20100	Plasma Adjust	Could not adjust Plasma Gas
20110	Shield Adjust	Could not adjust Shield Gas
20120	Preflow Adjust	Could not adjust Preflow Gas
20130	Postflow Adjust	Could not adjust Postflow Gas
20140	Marking Adjust	Could not adjust Marking Gas (Automatic Gas Console)
20160	N2 Mix Adjust	Could not adjust N2 Mix Gas
20170	O2 Mix Adjust	Could not adjust O2 Mix Gas
20200	O2 Low	O2 Input Pressure is low
20210	N2 Low	N2 Input Pressure is low
20220	Argon Low	Argon Input Pressure is low
20230	O2N2 Low	Air Input Pressure is low
20240	H17 Low	H17 Input Pressure is low
20250	O2 High	O2 Input Pressure is high
20260	N2 High	N2 Input Pressure is high
20270	Argon High	Argon Input Pressure is high
20280	O2N2 High	Air Input Pressure is high
20290	H17 High	H17 Input Pressure is high
20300	PS Quiet	Lost CAN communication with Power Supply
20310	PC Quiet	Lost CAN communication with Plasma Controller

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General Troubleshooting

The following contains general troubleshooting guidelines for the Spirit system. Please contact KALIBURN technical support for any issues not covered in this section. Before any tests are performed, make sure that all system fuses are good; remove top cover of power supply to check these fuses.

Problem	Possible Cause
Power supply indicator (white light) will not illuminate	1. Primary disconnect fuse blown. 2. Internal power supply fuse is blown (F1A, F1B). 3. Power supply indicator light is burned out or the associated wiring is bad. 4. Control Transformer or associated wiring bad.
Power Supply will not energize after choosing ON and then SELECT on the MGC.	1. ISC door open. 2. Low coolant level. 3. Fuse is blown (F1-F6). 4. Faulty OFF Button or associated wiring. 5. Off Relay faulty.
Power supply will not stay on after choosing ON and then SELECT on the MGC.	1. Faulty DSP board. 2. Off Relay faulty.
No arc at the torch	1. Incorrect torch consumables installed. 2. Incorrect gas pressure settings. 3. Pilot arc transistor (PAT) is not operating properly. Check the PAT LED (D43) on the DSP microprocessor board. 4. Damaged or loose torch lead connections. 5. Shorted torch or torch leads. Check the continuity between the Electrode lead and the Nozzle lead to make sure they are not shorted. 6. Open torch or torch leads. Check the continuity from the Electrode lead to the torch electrode and the Nozzle lead to the large brass body of the torch.
The arc will not transfer to the workpiece	1. Loose work ground connection. 2. Pierce height too high. 3. Incorrect, damaged, or worn consumables.

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Problem	Possible Cause
Primary power has been applied to the system, but the manual gas console screen is blank	1. Check power/communications CAN cable connection on back of manual gas console. 2. Check for blown DIN rail fuse. 3. Check for 120v on pins of power/communications CAN cable at back of the manual gas console.
The manual gas console screen is on, but the screen doesn't work	1. Cycle primary power to the Spirit system. 2. Check the connection of the ribbon cable that connects the keypad to the DSP PCB in the manual gas console.
Gas pressures will not adjust properly	1. Wrong consumables installed in torch. 2. Loose pressure transducer cable on PC board in the MGC. 3. Check connectors on the MGC valve associated with the malfunction.
Low pressure error	1. Supply gas pressure(s) less than 120 psi.
Pressure error during cut	1. Supply gas pressure(s) fluctuating during cut.
Liquid or torch coolant leaking from drain hole in torch handle.	Infrequent dripping from the drain hole may be condensation; no action is required. Noticeable flow from the drain hole indicates a problem with the torch leads and/or connections. 1. Check for damaged or loose torch lead connections within the torch handle.

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Chopper Test Procedure

WARNING: Only qualified maintenance personnel should perform the chopper test procedure. The system utilizes potentially fatal A.C. and D.C. voltages. All maintenance should be performed with safety in mind.

Use extreme caution when working near the power conversion module (i.e., chopper). The large electrolytic capacitors store large amounts of energy even after power has been removed from the system. Wait at least five minutes after turning off power, and then use a voltmeter to verify that the capacitors are fully discharged before touching the power conversion module.

Capacitor failure can injure and/or cause property damage. If troubleshooting requires the system to be powered with the enclosure panels removed, remain clear of the capacitors. Failure of a capacitor can result in a sudden release of stored energy causing rupture of the capacitor case.

IMPORTANT: Depending upon the system, there are one, two or three chopper assemblies in the power supply. The following steps must be performed on each chopper with the other chopper(s) disabled. To disable a chopper, remove the plug from J1 on the chopper PCB (see drawing on next page).

1. Remove primary power from the Spirit system.

2. Open the impulse start console door and disconnect the Green P1 Plug from the impulse start PCB. Close the impulse start console door to activate the door interlock switch.

3. Remove the top, left, right and front covers from the power supply to expose the DSP PCB, input and output terminal blocks and chopper(s).

4. Remove the Electrode, Work and Nozzle leads from the output terminal block, which is located on the left side of the unit.

5. Ensure the torch head (with a full set of consumables) is properly installed onto the torch base.

6. Apply primary power to the Spirit system.

7. Release the OFF Button on the Plasma Controller or Manual Gas Console to enable the system. Press or SELECT the ON Button to energize the system. After the gases set, prepare to apply a start signal to the unit.

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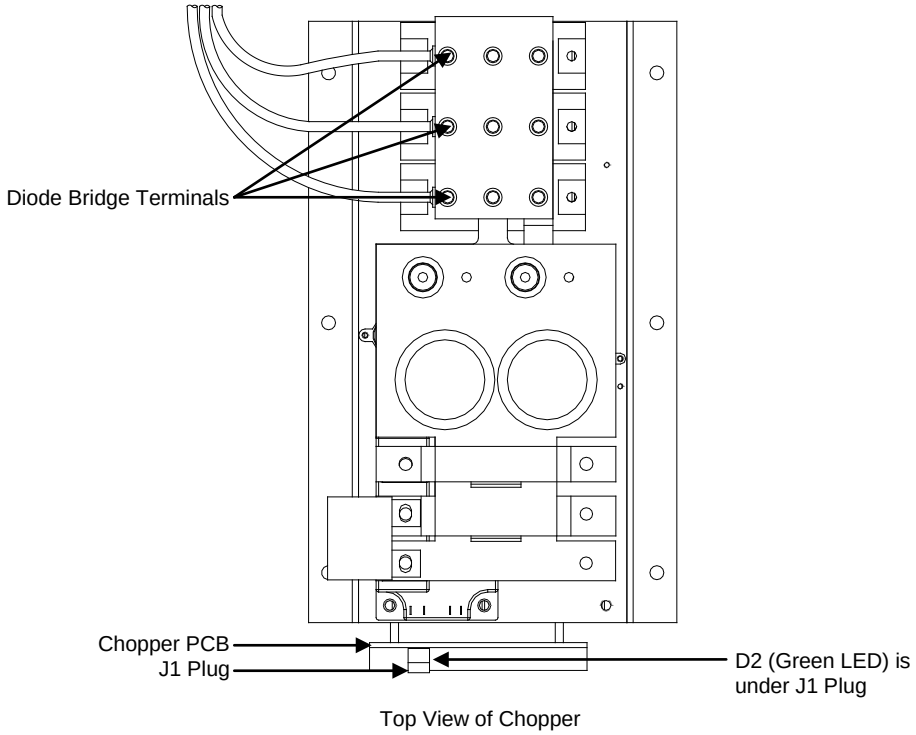
8. With a start signal applied, check the three phase voltage input to each chopper at the diode bridge terminals (three screws on the left side of each chopper). Refer to TABLE 1 for the proper three phase AC voltage.

   Note that the system will only energize for approximately two seconds each time a start signal is applied.

   If the voltage is not present, check for primary voltage on the main contactor (CON 1) and on the primary side of the power transformer.



Top View of Chopper

9. With a start signal applied, check for the proper DC voltage (refer to TABLE 1) at the output terminal block between Electrode and Work, which is located on the left side of the unit.

   If the proper DC voltage is present, the chopper is working properly.

TABLE 1

	Chopper 1		Chopper 2		Chopper 3	
	3 Phase AC	OCV (DC)	3 Phase AC	OCV (DC)	3 Phase AC	OCV (DC)
Spirit II 400 Amp	255	370	255	370	255	370
Spirit II 275 Amp	225	325	225	325	N/A	N/A
Spirit II 150 Amp	208	300	N/A	N/A	N/A	N/A

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10. If the proper DC voltage is not present at the output terminal block, check the 200 amp fuse F9 (chopper 1), fuse F10 (chopper 2) or fuse F11 (chopper 3) located on the bottom right of the output bus bars.

    If the fuse is open, replace chopper and fuse.

11. If the fuse(s) is good, check if the chopper PWM LED illuminates when a start signal is applied:

    a) check D24 on the DSP PCB – If D24 doesn't illuminate, replace DSP PCB.

    b) check D2 on the chopper PCB – If D2 doesn't illuminate green, go to step 12.

12. Check PCB power to the chopper from the DSP:

    a) Push the OFF Button.

    b) Disconnect the J1 plug from the chopper PCB.

    c) Leave the OFF Button pushed in.

    d) With a digital voltmeter, measure the following voltages on the J1 plug:

J1-5 (ground) to J1-1	+15vdc Supply
J1-5 (ground) to J1-2	+5vdc Supply
J1-5 (ground) to J1-3	+5vdc (PWM Signal)

    If ALL of the voltages are present, replace chopper. If any of the voltages are not present, go to step 13:

13. Remove primary power from the Spirit system. Check cable continuity between the chopper PCB and DSP PCB. Use a digital voltmeter set up to read resistance (ohms) and make the following measurements:

    Chopper (1) J1-1 to DSP J7-1
    Chopper (1) J1-2 to DSP J7-2
    Chopper (1) J1-3 to DSP J7-3
    Chopper (1) J1-5 to DSP J7-4

    Chopper (2) J1-1 to DSP J8-1
    Chopper (2) J1-2 to DSP J8-2
    Chopper (2) J1-3 to DSP J8-3
    Chopper (2) J1-5 to DSP J8-4

    Chopper (3) J1-1 to DSP J9-1
    Chopper (3) J1-2 to DSP J9-2
    Chopper (3) J1-3 to DSP J9-3
    Chopper (3) J1-5 to DSP J9-4

    If ALL of the continuity readings are good, replace DSP PCB.

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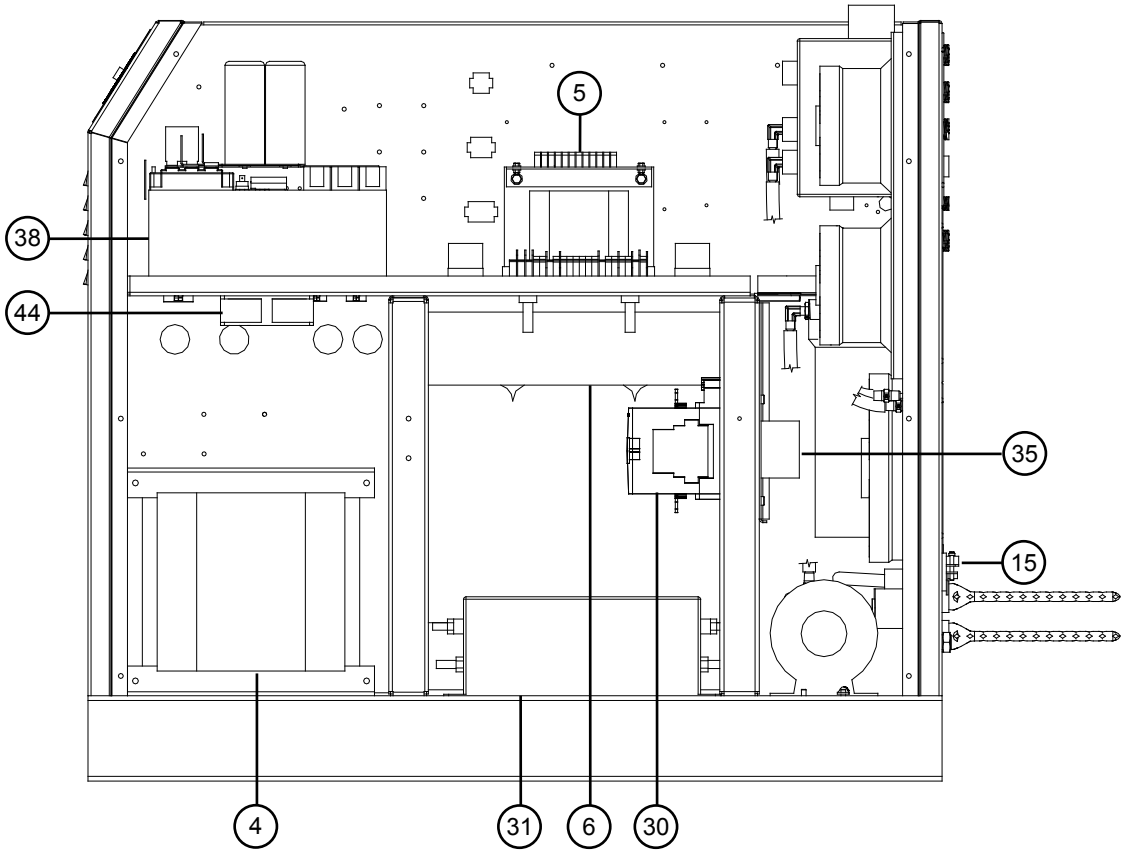
Section 7: Parts List
Power Supply (BK300211 - BK300219)
Right Side View

Item	Part Number	Quantity	Description
4	BK707155	1	L1 Inductor
5	BK706409 BK706410	1	T2 Control Transformer, 200-480 V / 60 Hz T2 Control Transformer, 600 V / 60 Hz
6	BK706405 BK706501	1	T1 Main Transformer, 200-480 V / 60 Hz / 3Ø T1 Main Transformer, 600 V / 60 Hz / 3Ø
15	BK709105	1	Strain Relief
30	BK708121	1	CON 1 Contactor
31	BK702076	1	EMI Filter, 380/415 V units only
35	BK709167	1	TB5 3 Phase Input Power Terminal Block
38	BK300250	1	Chopper Assembly
44	BK200204	1	Fan (4.7")



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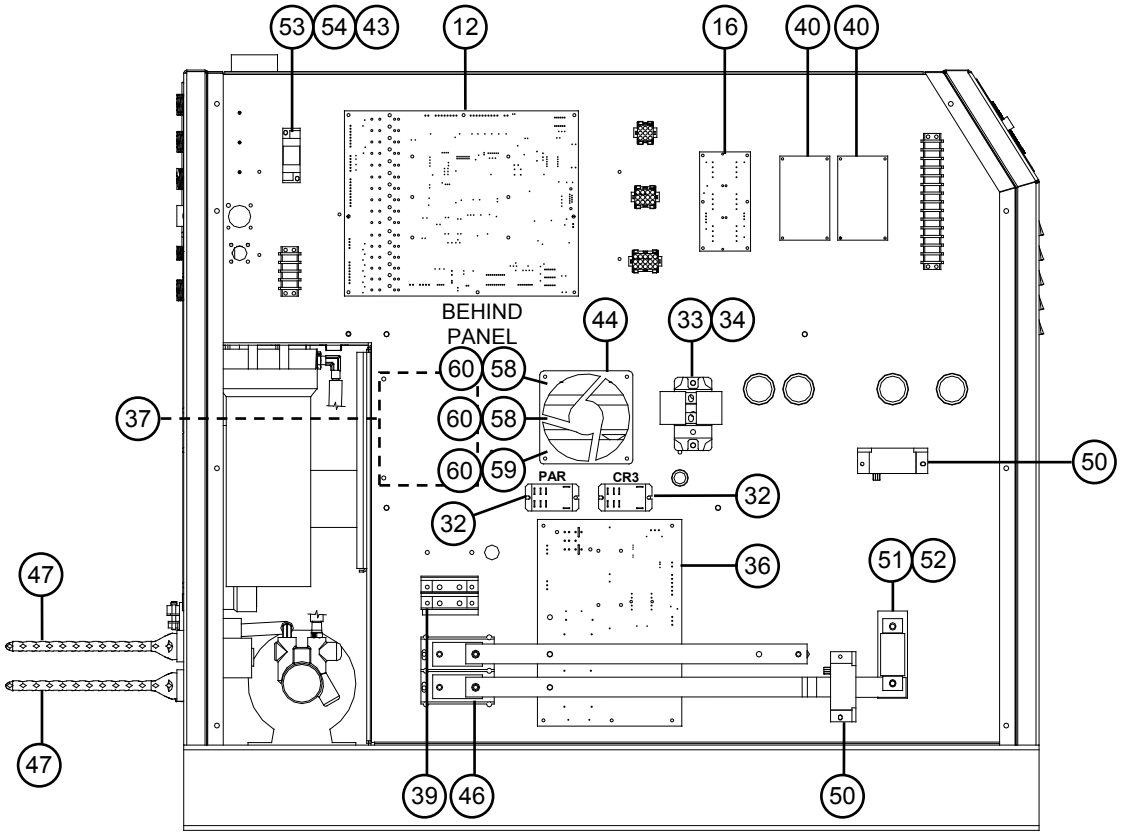
Power Supply (BK300211 - BK300219)
Left Side View

Item	Part Number	Quantity	Description
12	BK300101	1	Printed Circuit Board (PCB), Microprocessor (DSP)
16	BK300112	1	Printed Circuit Board (PCB), A.C. Detect
32	BK708118	2	CR3/PAR Relay
33	BK705011	1	PAT IGBT
34	BK702075	2	PAT IGBT Filter Capacitor
36	BK300108	1	Printed Circuit Board (PCB), Power Supply Output (I/O)
37	BK301200	1	(Optional) Printed Circuit Board (PCB), Voltage Divider
39	BK709117	1	I/O Terminal Block (small)
40	BK280003	2	Power Supply, 24VDC
43	BK708105	2	Relay Hold Down Clip
44	BK200204	1	Fan (4.7")
46	BK709252	1	I/O Terminal Block (large)
47	BK709227	2	Strain Relief
50	BK284029	2	Current Sensor
51	BK300130	1	F9 Fuse, 200A
52	BK300129	1	F9 Fuse Holder
53	BK300153	1	Off Relay
54	BK300156	1	Off Relay Socket
58	BK701165	2	R1/R2 Resistor, 300W, 3 Ohm
59	BK701141	1	R3 Resistor, 300W, 2 Ohm
60	BK701083	3	Resistor Mounting Hardware



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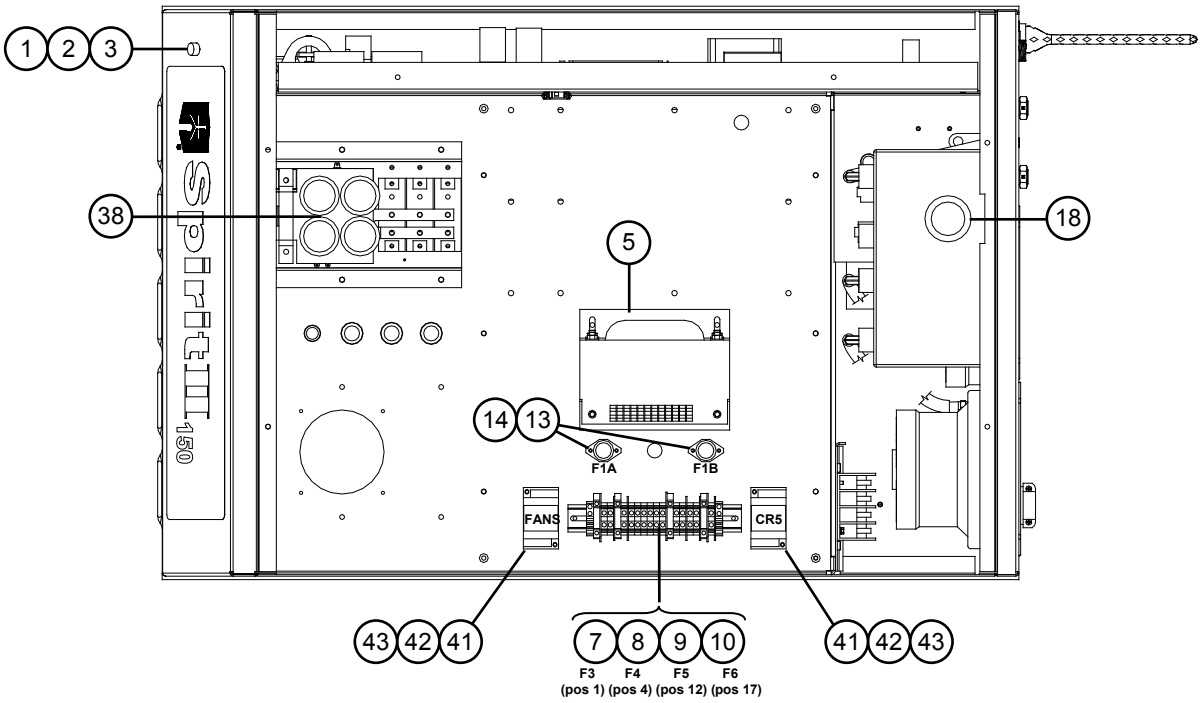
Power Supply (BK300211 - BK300219)
Top View

Item	Part Number	Quantity	Description
1	BK501163	1	Light Housing
2	BK501164	1	Bulb
3	BK501162	1	White Lens
5	BK706409 BK706410	1	T2 Control Transformer, 200-480 V / 60 Hz T2 Control Transformer, 600 V / 60 Hz
7	BK709359	1	F3 Fuse, 5A, Slow Blow
8	BK709358	1	F4 Fuse, 5A, Medium Blow
9	BK709358	1	F5 Fuse, 5A, Medium Blow
10	BK709360	1	F6 Fuse, 6.3A
13	BK709061	2	F1A/F1B Fuse Holder
14	BK709128	2	F1A/F1B Fuse, FNM 6.25A
18	BK500518	1	Coolant Reservoir Cap/Level Gauge
38	BK300250	1	Chopper Assembly
41	BK708103	2	Fan/CR5 Relay
42	BK708104	2	Relay Socket
43	BK708105	4	Relay Hold Down Clip



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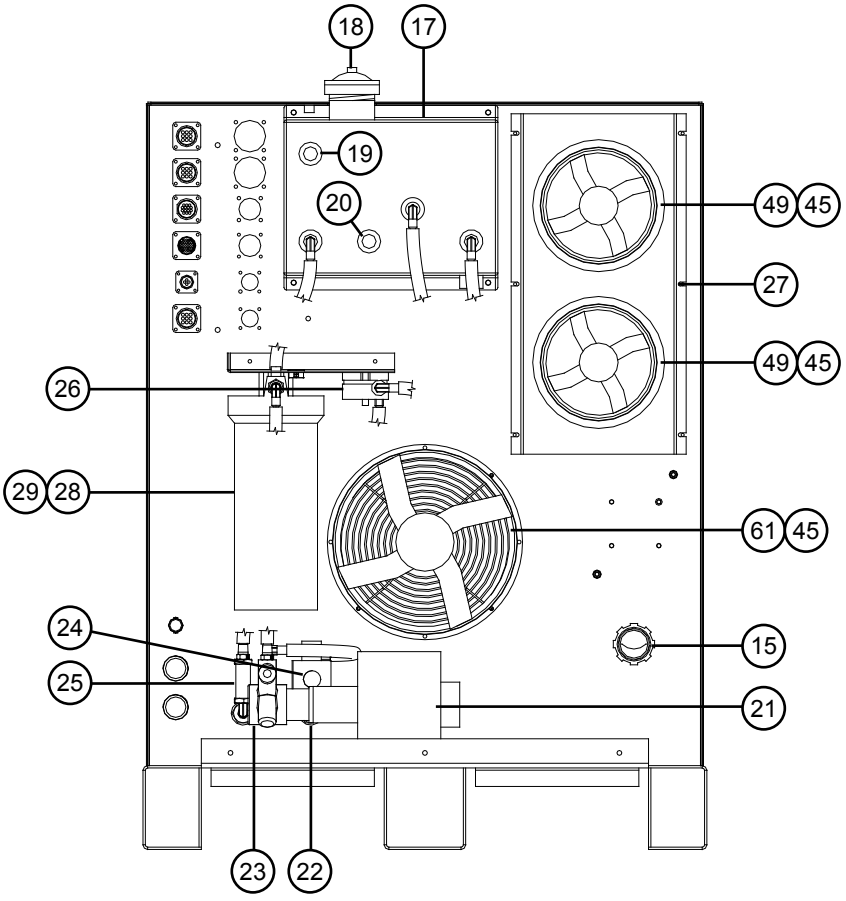
Power Supply (BK300211 - BK300219)
Cooling Section View

Item	Part Number	Quantity	Description
15	BK709105	1	Strain Relief
17	BK200092	1	Coolant Reservoir, without Fittings or Cap
18	BK500518	1	Coolant Reservoir Cap/Level Gauge
19	BK300135	1	Coolant Level Switch
20	BK505024	1	Coolant Temperature Switch
21	BK500052	1	Coolant Pump Motor, 1/3hp-230V-50/60 Hz
22	BK500513	1	V-Band Clamp
23	BK500511	1	Coolant Pump, 70 gph
24	BK708061	1	Solenoid Valve, 220/240VAC
25	BK715118	1	Check Valve, Coolant Return
26	BK300134	1	Coolant Flow Sensor
27	BK260250	1	Heat Exchanger
28	BK500509	1	Coolant Filter Housing
29	BK500510	1	Coolant Filter / Deionization Cartridge
45	BK500526	3	Fan Guard (Mounted Outside)
49	BK500525	2	Fan (6")
61	BK284031	1	Fan (10")



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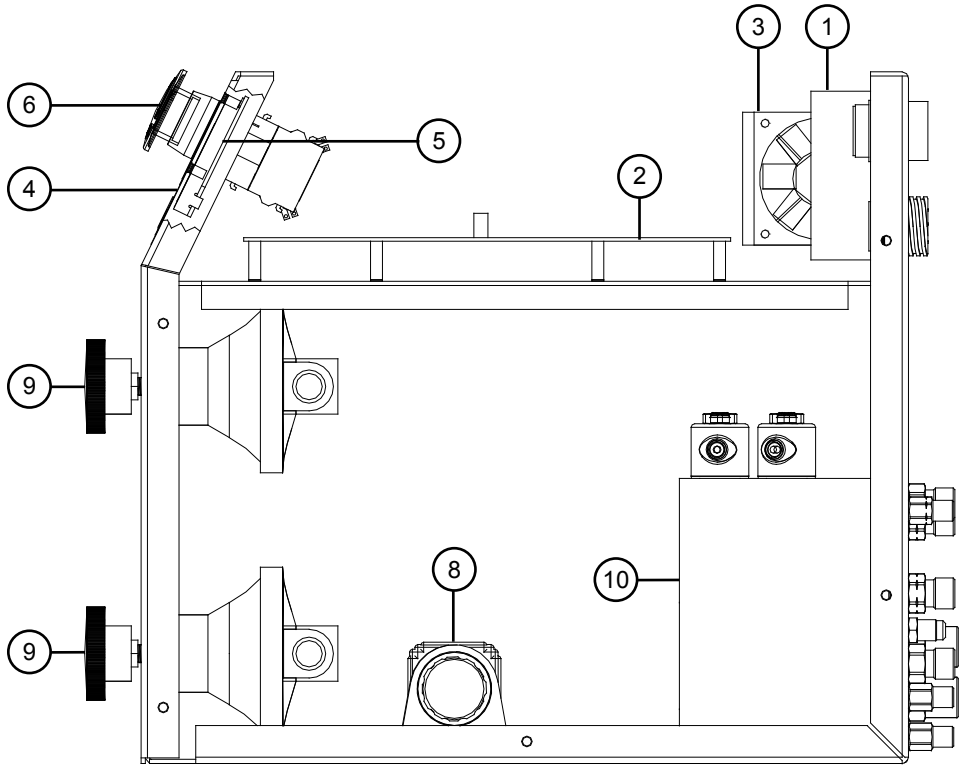
Manual Gas Console (BK300600)
Right Side View

Item	Part Number	Quantity	Description
1	BK300412	1	Power Supply, 24VDC, 8.3A
2	BK300301	1	Printed Circuit Board (PCB), Gas Console DSP
3	BK280030	1	Fan, 24VDC
4	BK300602	1	Keypad
5	BK300603	1	LCD Display
6	BK708111	1	Switch, Pushbutton (OFF Button)
8	BK280032	1	Marking Regulator, 0-60 PSI, 145 PSI Max Input
9	BK500570	2	Plasma/Shield Regulator, 0-125 PSI
10	BK300605	1	Manifold Block, Gas Outputs



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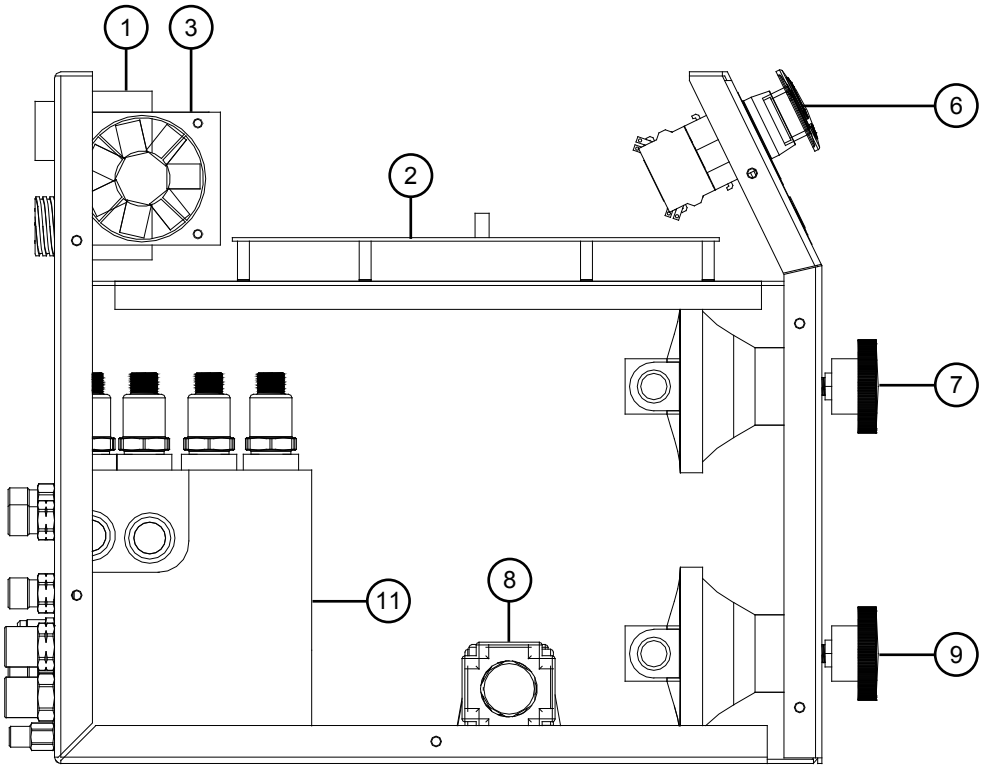
Manual Gas Console (BK300600)
Left Side View

Item	Part Number	Quantity	Description
1	BK300412	1	Power Supply, 24VDC, 8.3A
2	BK300301	1	Printed Circuit Board (PCB), Gas Console DSP
3	BK280030	1	Fan, 24VDC
6	BK708111	1	Switch, Pushbutton (OFF Button)
7	BK500562	1	Preflow Regulator, 0-60 PSI
8	BK280032	1	Marking Regulator, 0-60 PSI, 145 PSI Max Input
9	BK500570	1	Postflow Regulator, 0-125 PSI
11	BK300414	1	Manifold Block, Gas Inputs



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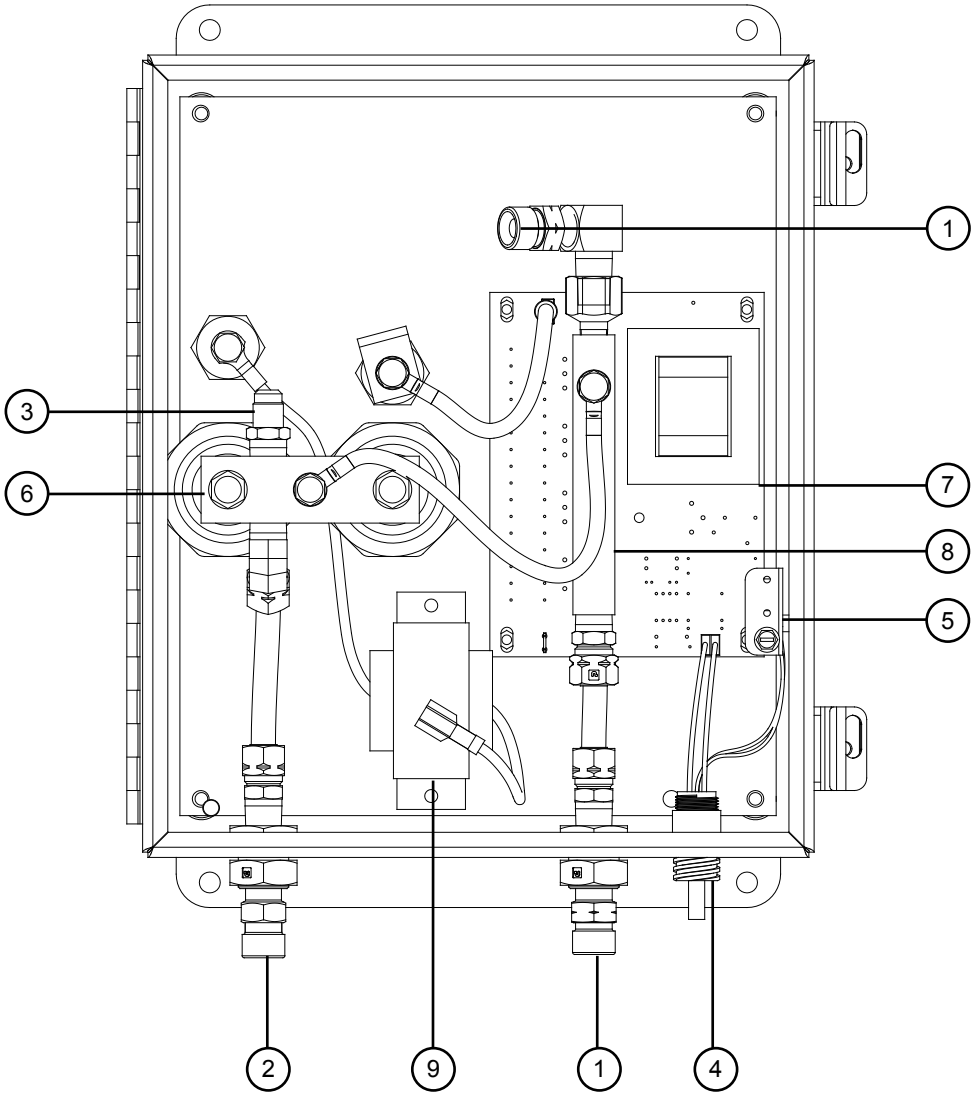
Impulse Start Console (BK300500)

Item	Part Number	Quantity	Description
1	BK715051	2	Coolant Return Fitting (left hand)
2	BK715050	1	Coolant Supply Fitting (right hand)
3	BK715021	1	Coolant Supply Fitting (right hand)
4	BK709001	1	4 Pin Receptacle
5	BK708057	1	Door Interlock Switch
6	BK500503	1	Cathode Manifold
7	BK980200	1	Printed Circuit Board (PCB), Impulse Start
8	BK980201	1	Impulse Start Manifold
9	BK707300	1	Inductor



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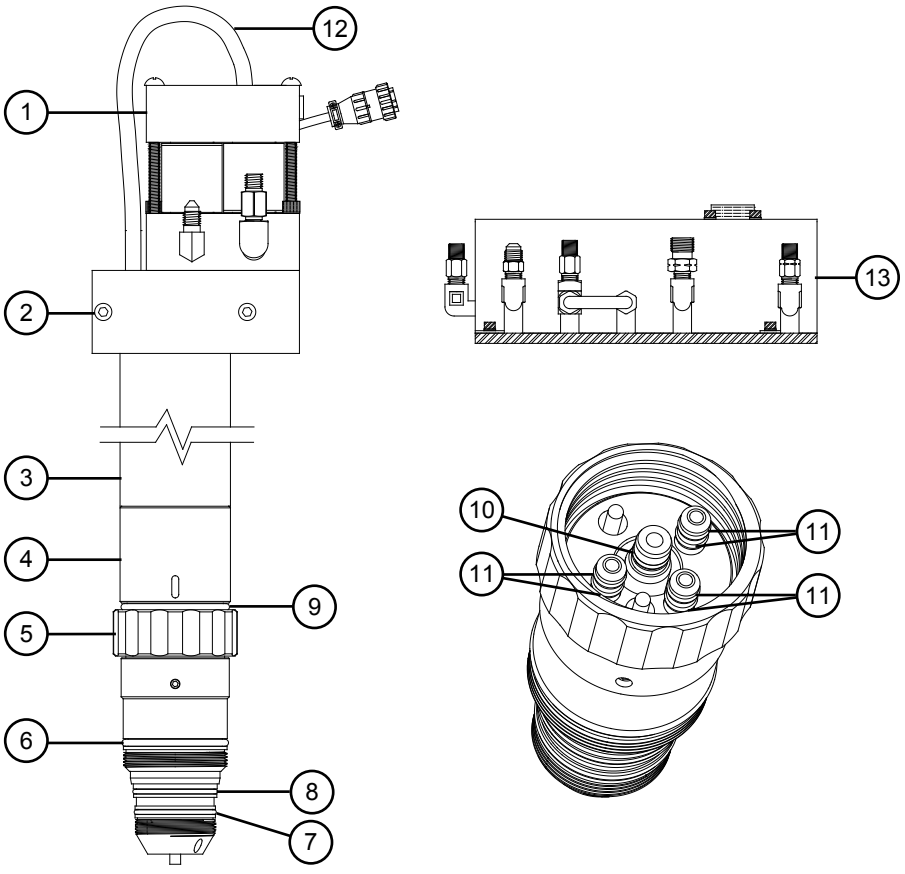
Torch and Manifold Assemblies

Item	Part Number	Quantity	Description
1	BK284214	1	2-Gang Manifold (includes Bracket)
2	BK277195	1	2-Gang Manifold Bracket
3	BK278001 BK278018	1	Torch Handle – Standard Torch Handle – Short
4	BK279000	1	Torch Base
5	BK279100 BK279060	1	Torch Head (Copper Electrode) Torch Head (Silver Electrode)
6	BK820209	1	O-ring (red)
7	BK500024	1	O-ring (blue)
8	BK500018	1	O-ring (red)
9	BK279013	1	O-ring (red) - indicator only, not a seal
10	BK279112	1	O-ring (red)
11	BK279113	6	O-ring (red)
12	BK284039	1	(17") Torch Solenoid Plasma Hose
13	BK280022	1	5-Gang Manifold for Manual Gas Console
Not shown	BK716012	1	O-ring Lubricant
Not shown	BK277056	1	Nozzle Removal Tool
Not shown	BK277086	1	Electrode Removal Tool Driver
Not shown	BK277087	1	Copper Electrode Removal Tool
Not shown	BK279061	1	Silver Electrode Removal Tool



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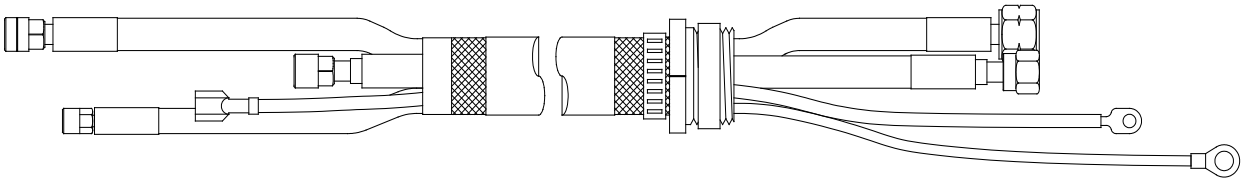
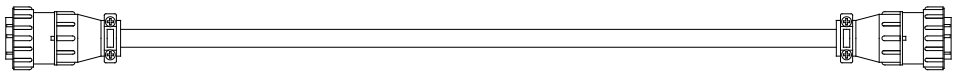
Shielded Torch Leads

Part Number	Length
BK284304-XX	Where -XX is the length in feet. Available in 5 foot increments up to 40 feet.



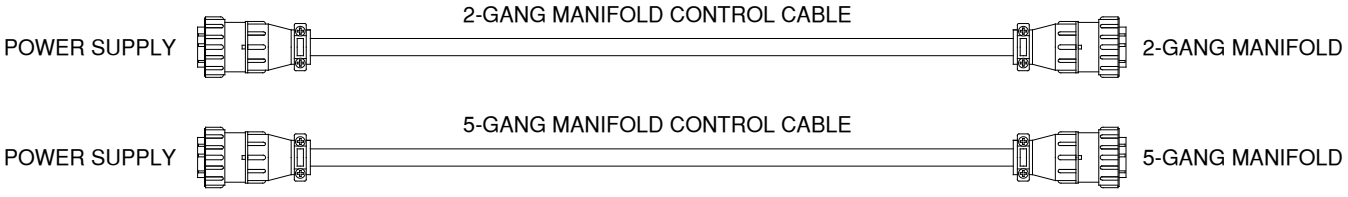
CAN Communication Cable and Termination Plug

Item	Part Number	Length
CAN Termination Plug	BK300408	N/A
CAN Cable	BK300177-XX	Where -XX is the length in feet. Available in 5 foot increments.



Manifold Control Cables

Item	Part Number	Length
2-Gang Manifold	BK280312-XX	Where -XX is the length in feet. Available in 5 foot increments.
5-Gang Manifold	BK280321-XX	



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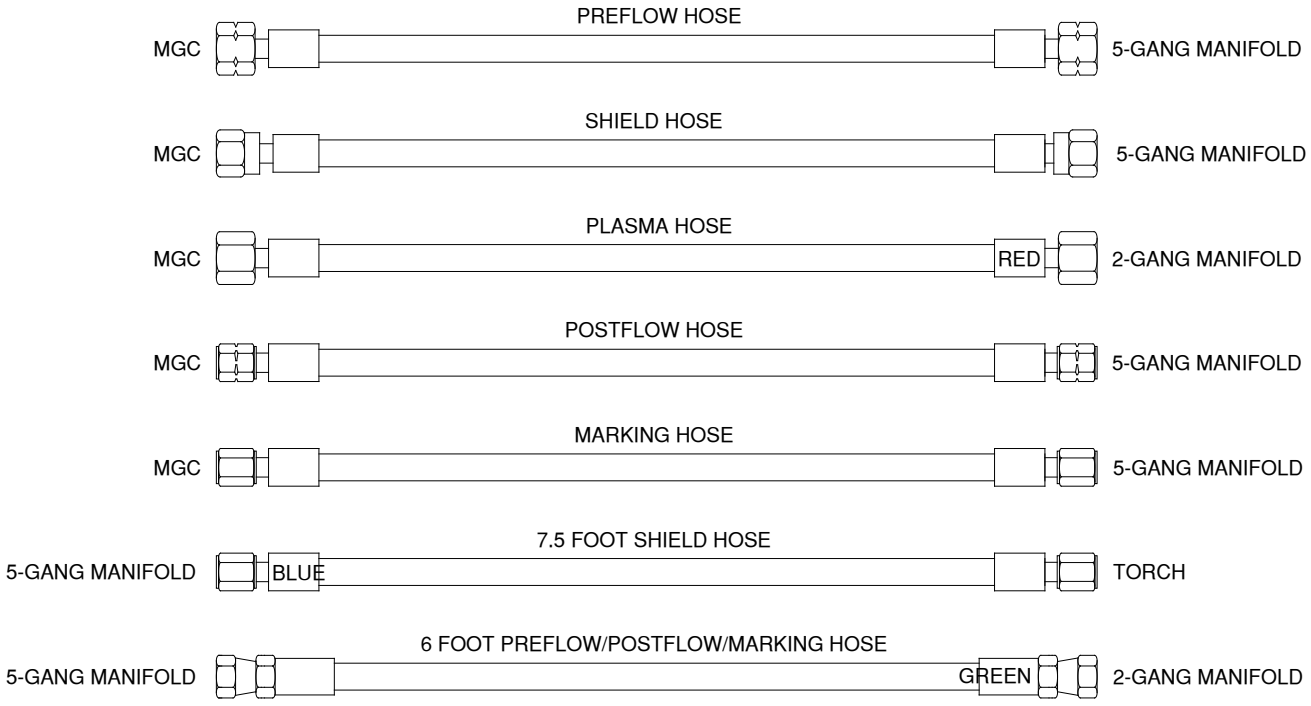
Gas Hose Package with MGC

Part Number	Length*
BK300085-20	20 ft. (6.1m)
BK300085-30	30 ft. (9.1m)
BK300085-40	40 ft. (12.2m)
BK300085-50	50 ft. (15.2m)
BK300085-60	60 ft. (18.3m)
**Custom lengths are available. Contact factory.*	



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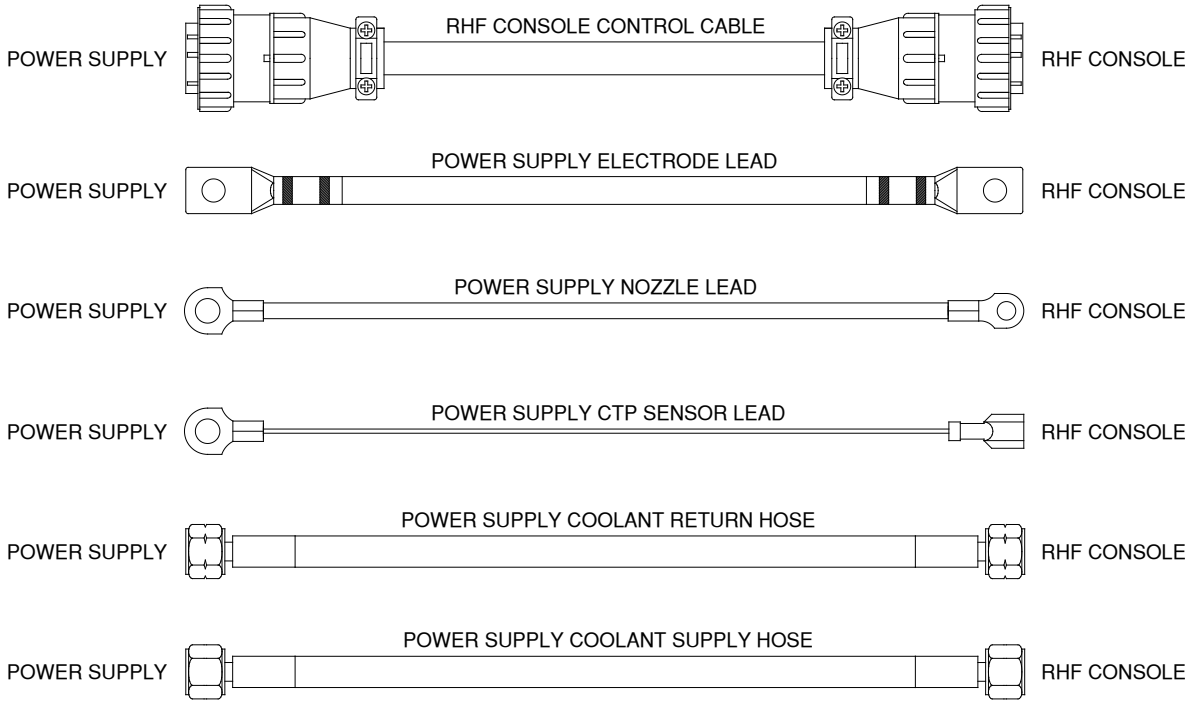
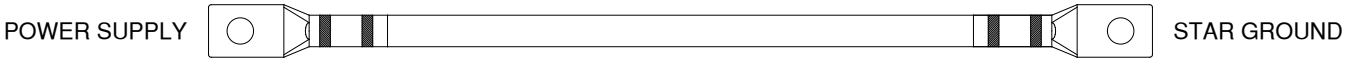
Coolant and Power Leads

Part Number (Non-CSA Systems)	Part Number (CSA Systems)	Length
BK280306-XX	BK288306-XX	Where -XX is the length in feet. Available in 5 foot increments.



Work Ground Lead

Part Number (Non-CSA Systems)	Part Number (CSA Systems)	Length
BK280318-XX	BK288318-XX	Where -XX is the length in feet. Available in 5 foot increments.



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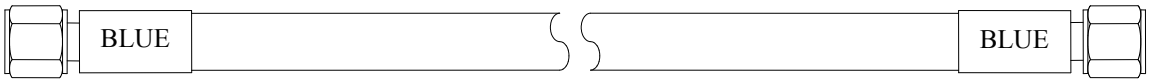
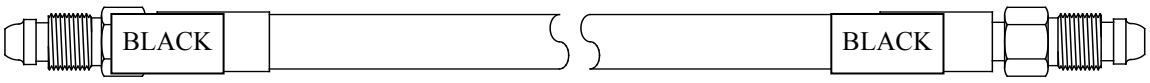
Oxygen Supply Gas Hose (Optional)

Part Number	Length
BK200362-25	25 ft. (7.6 m)
BK200362-50	50 ft. (15.2 m)



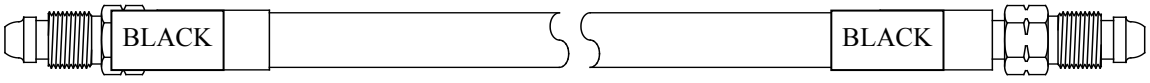
Nitrogen Supply Gas Hose (Optional)

Part Number	Length
BK200365-25	25 ft. (7.6 m)
BK200365-50	50 ft. (15.2 m)



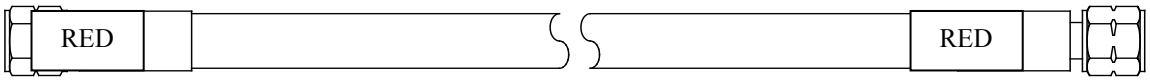
Air Supply Gas Hose (Optional)

Part Number	Length
BK200364-25	25 ft. (7.6 m)
BK200364-50	50 ft. (15.2 m)



H17 Supply Gas Hose (Optional)

Part Number	Length
BK200363-25	25 ft. (7.6 m)
BK200363-50	50 ft. (15.2 m)



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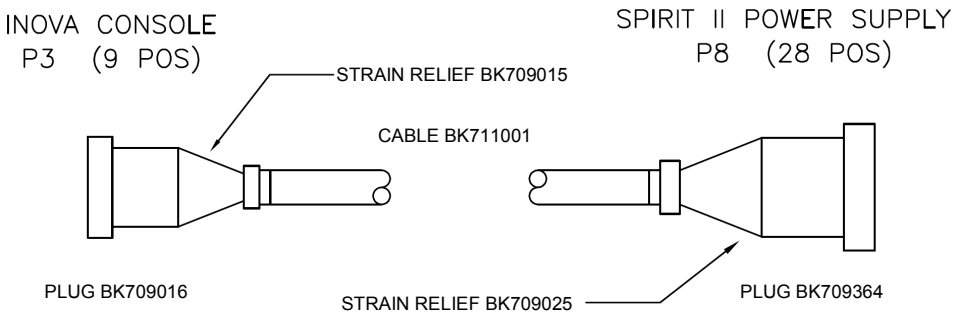
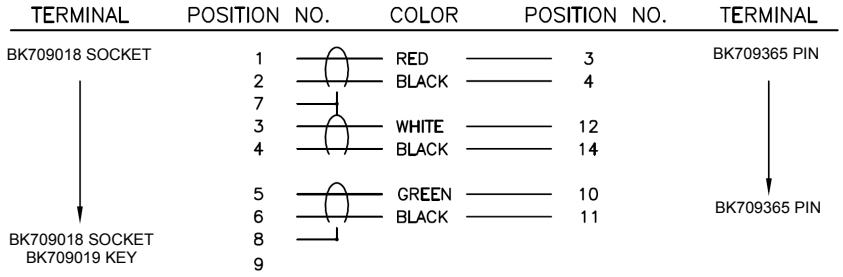
"CII" Cable (for Optional External Inova)

Part Number	Length
BK300902-XX	Where -XX is the length in feet. Available in 10 foot increments.





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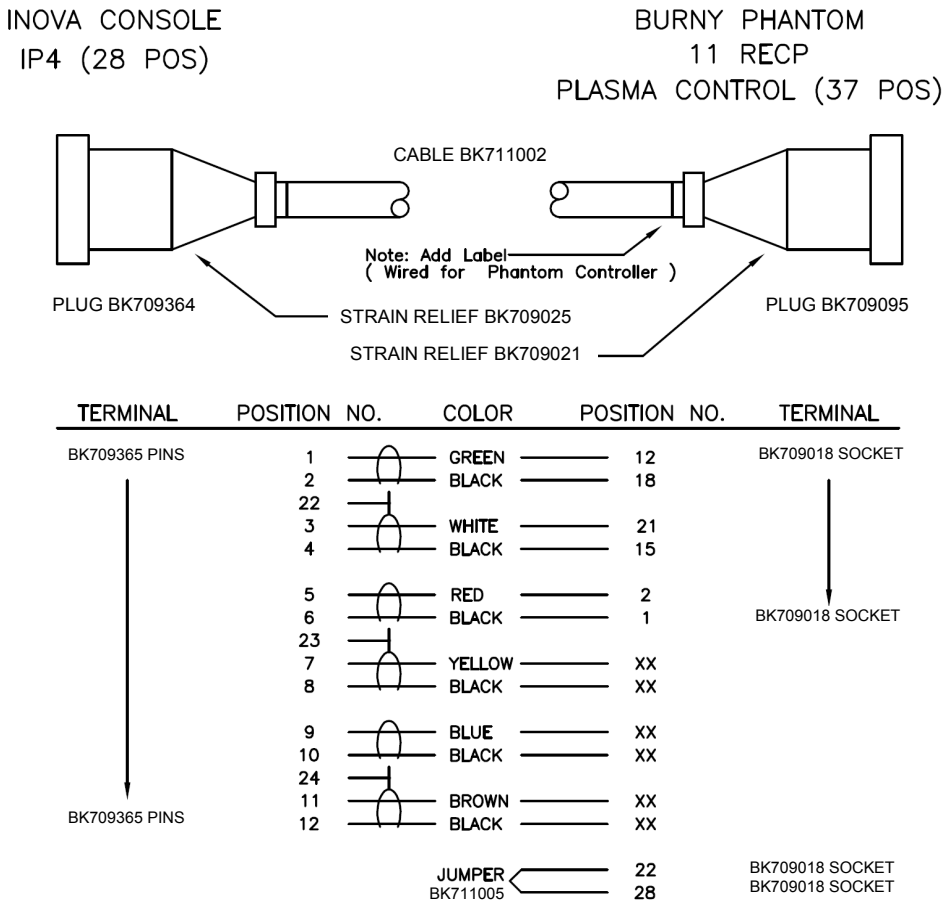
"FII" Cable (for Optional Internal Inova)

Part Number	Length
BK300903-XX	Where -XX is the length in feet. Available in 10 foot increments.



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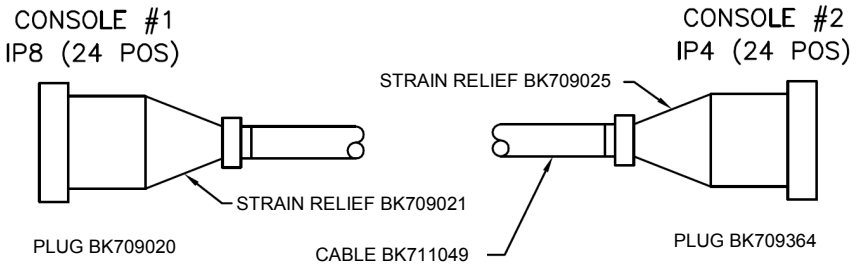
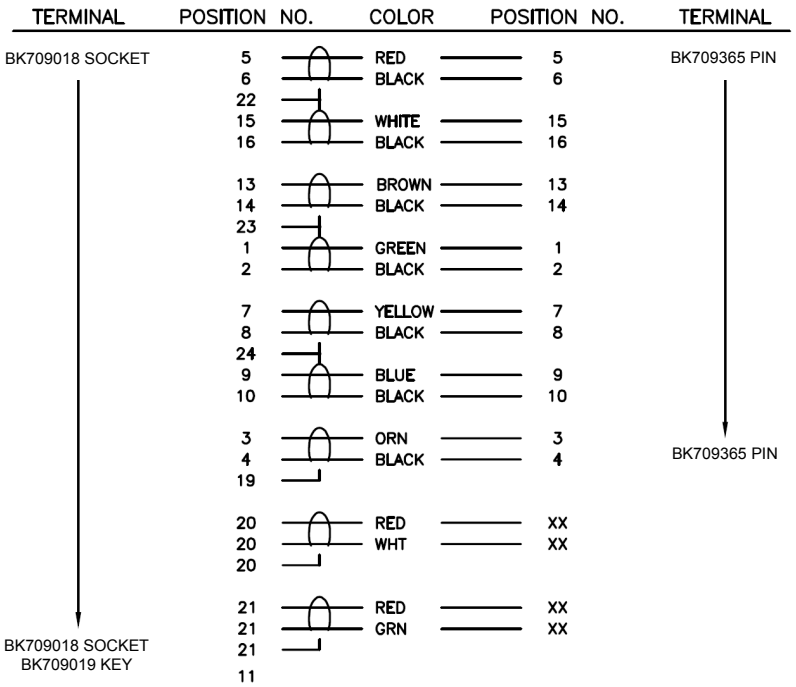
"JII" Cable (for Optional Internal Inova)

Part Number	Length
BK300904-XX	Where -XX is the length in feet. Available in 10 foot increments.





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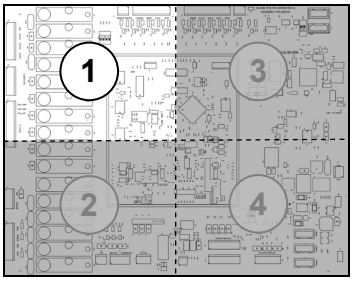
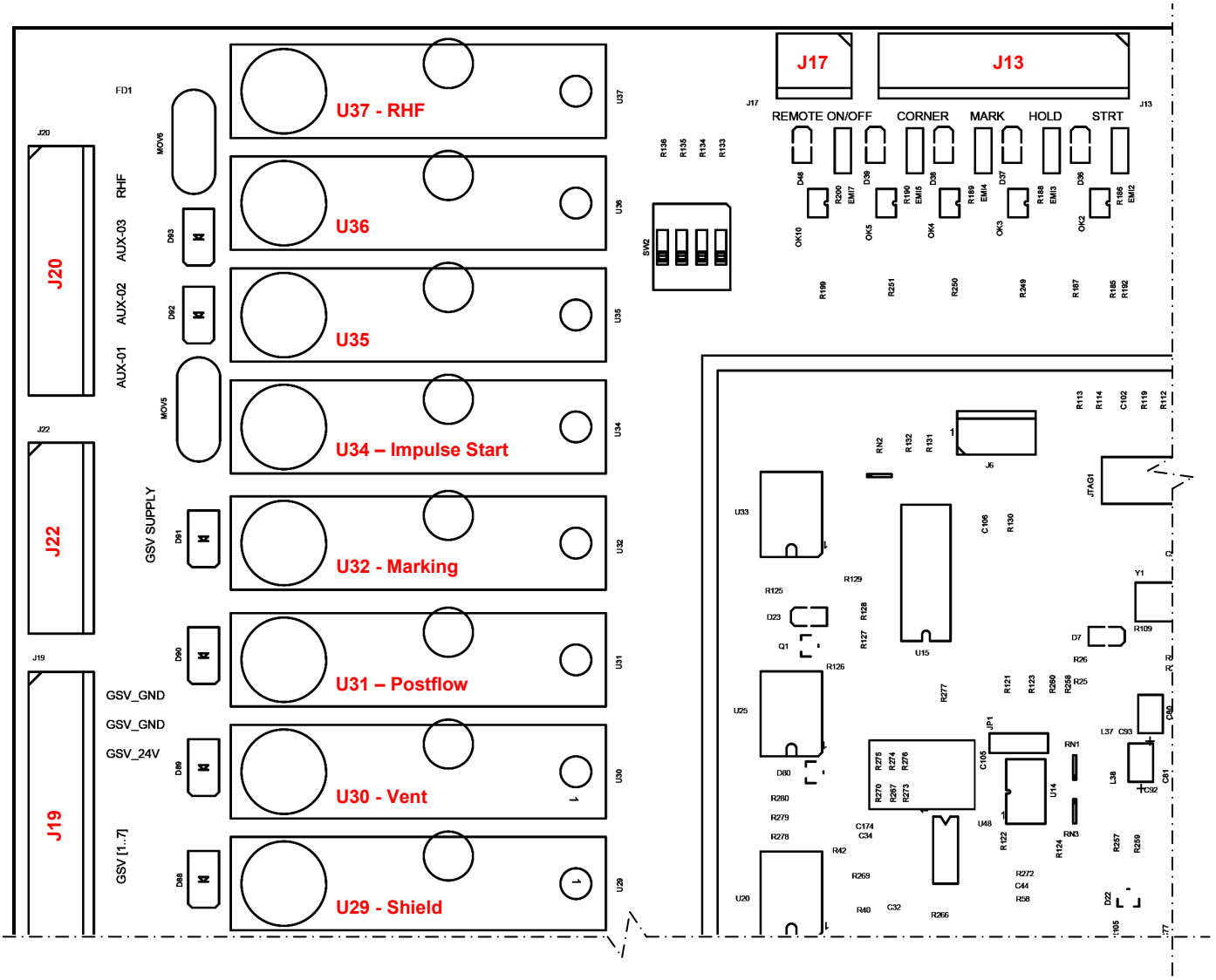
PCB Assemblies – Component Reference Locations

Power Supply, Microprocessor DSP (BK300101) – Quadrant 1



PCB Quadrant Map



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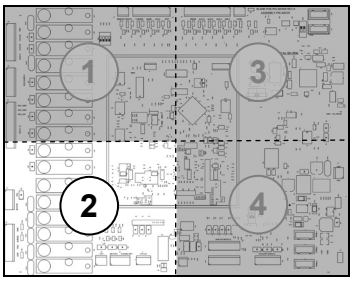
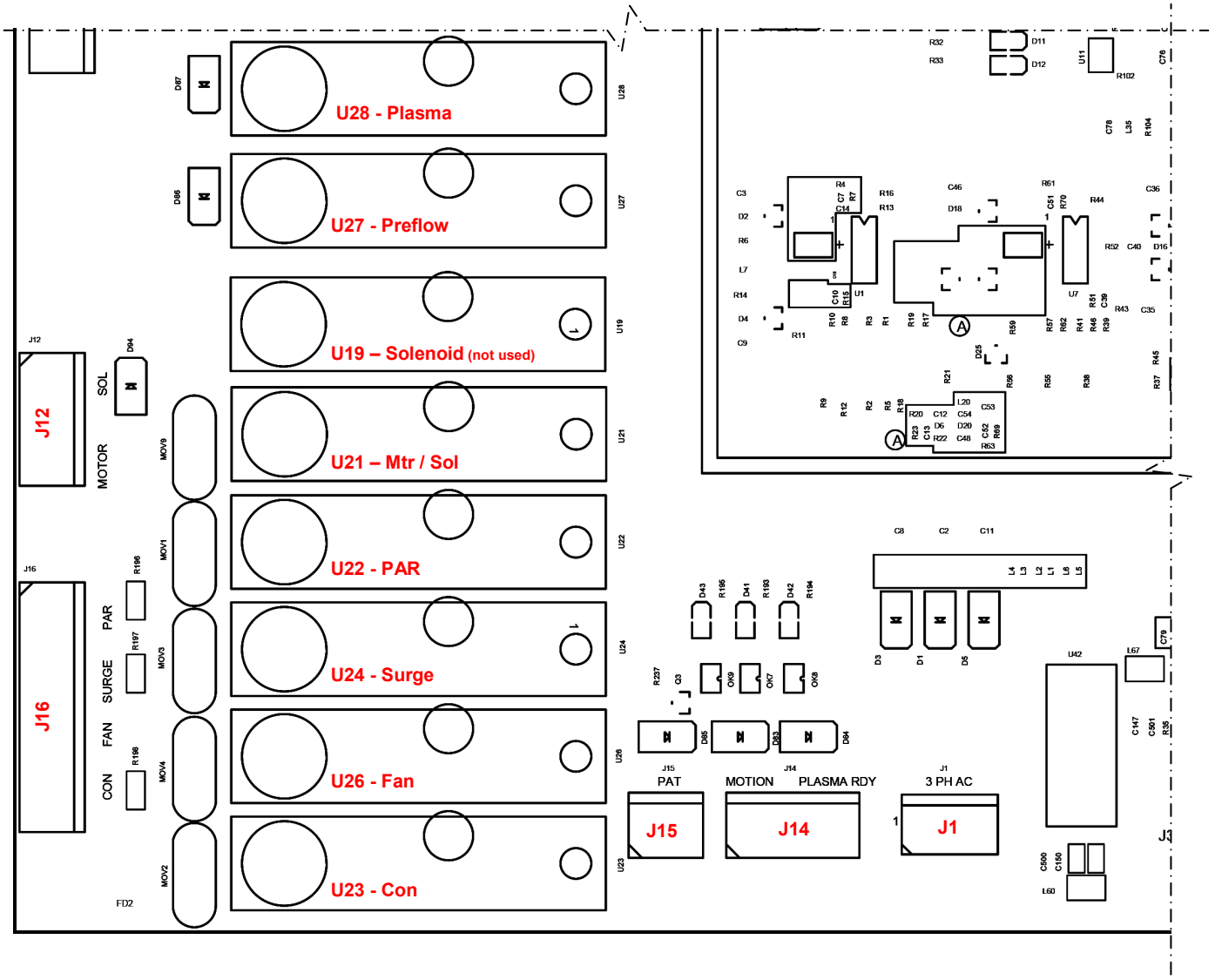
Power Supply, Microprocessor DSP (BK300101) – Quadrant 2



PCB Quadrant Map



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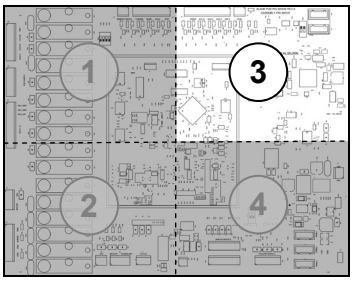
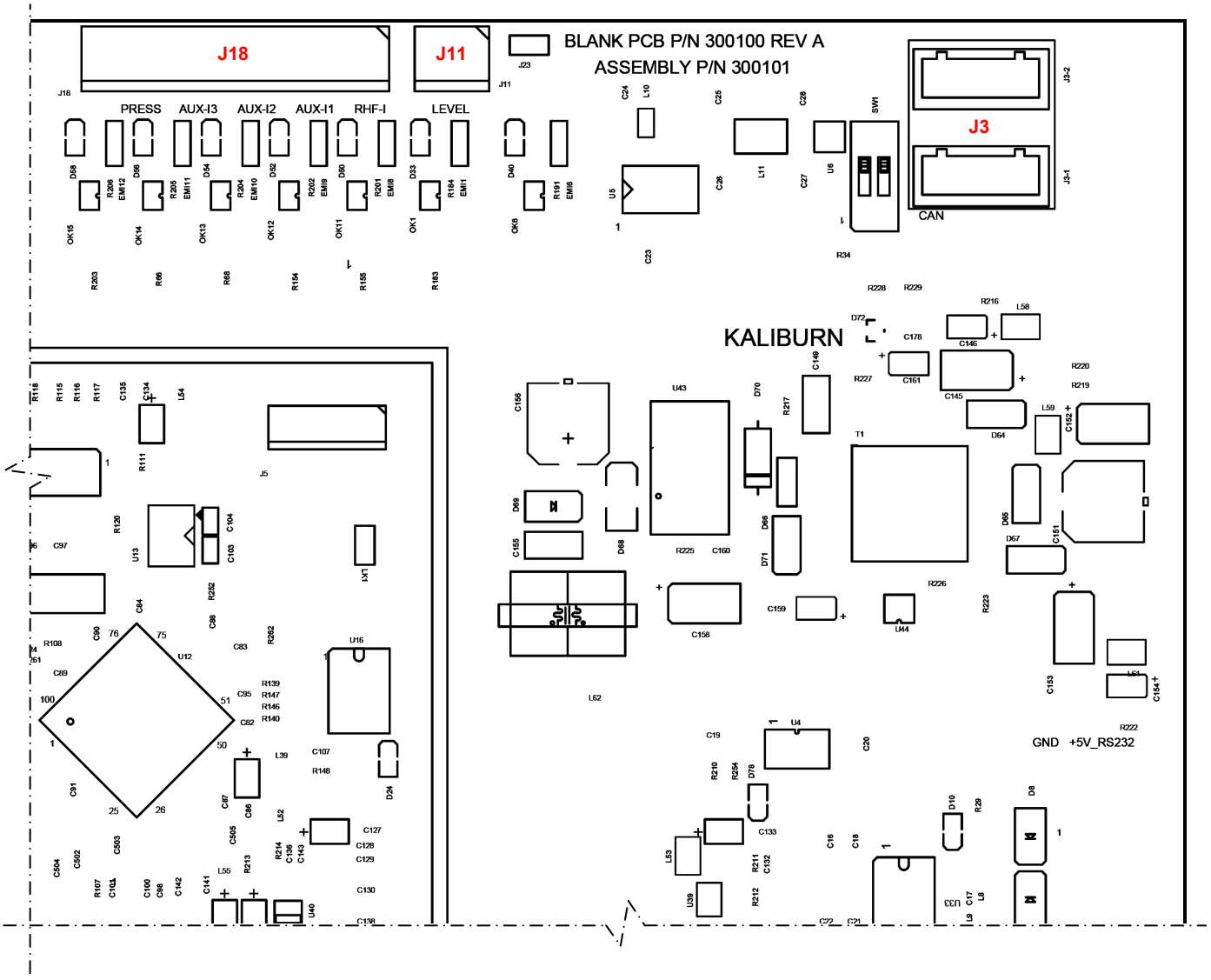
Power Supply, Microprocessor DSP (BK300101) – Quadrant 3



PCB Quadrant Map



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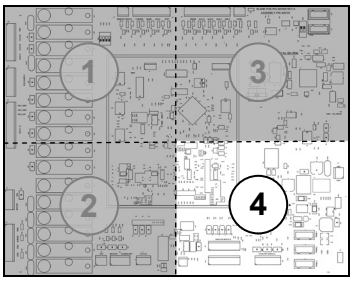
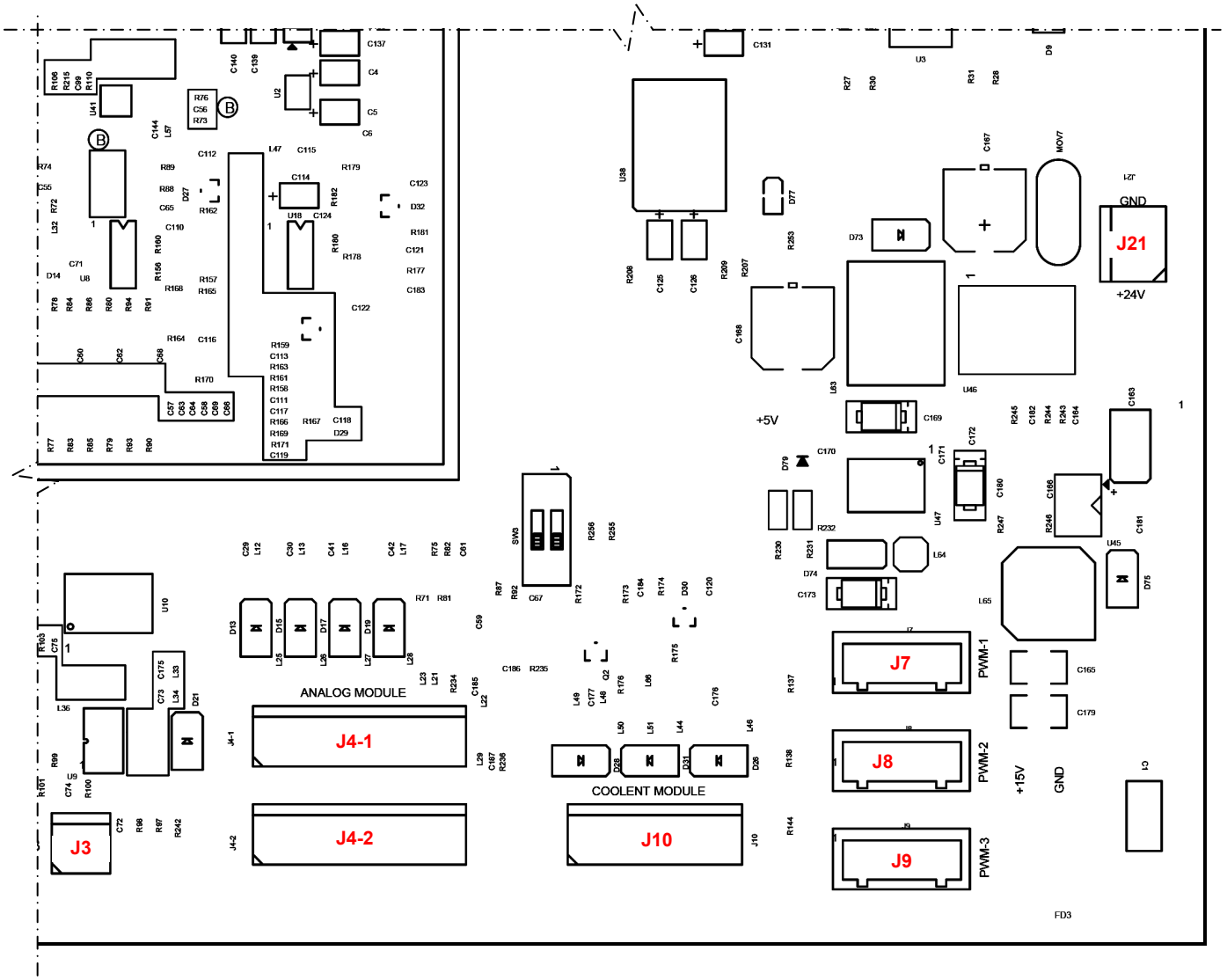
Power Supply, Microprocessor DSP (BK300101) – Quadrant 4



PCB Quadrant Map



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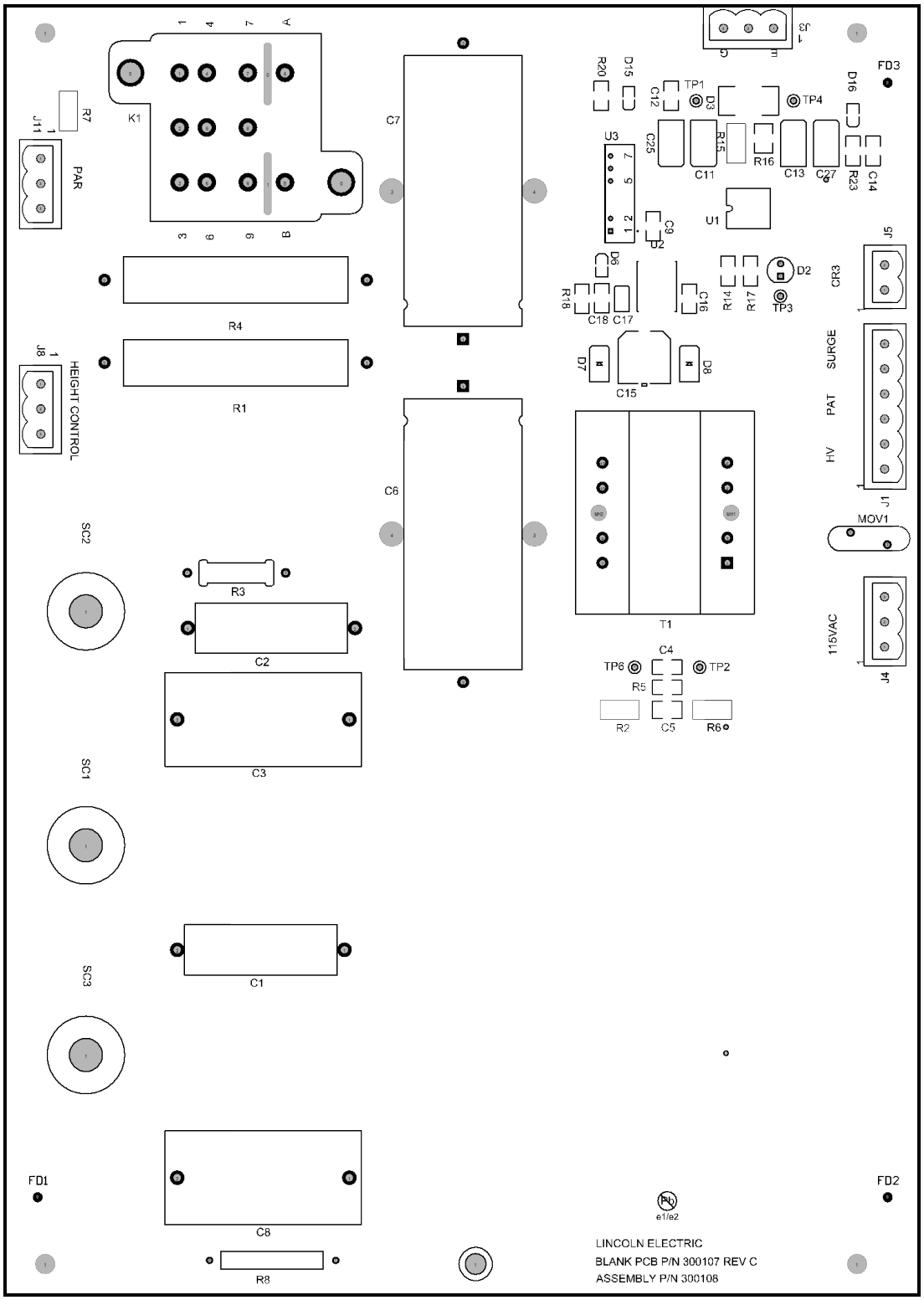
Power Supply, Output (BK300108)



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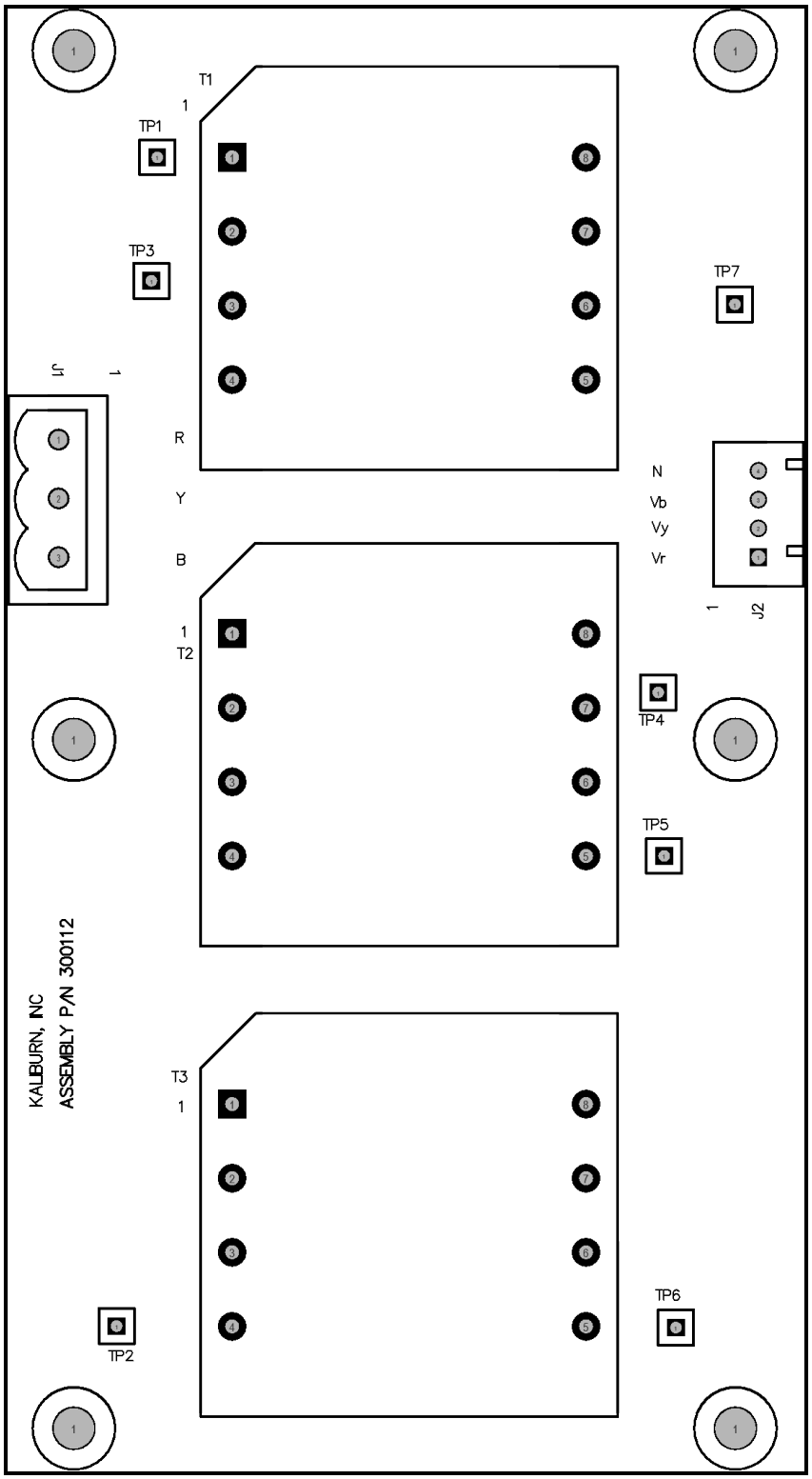
Power Supply, A.C. Detect (BK300112)



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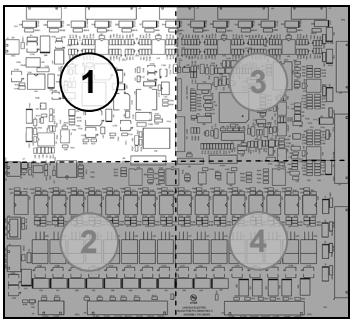
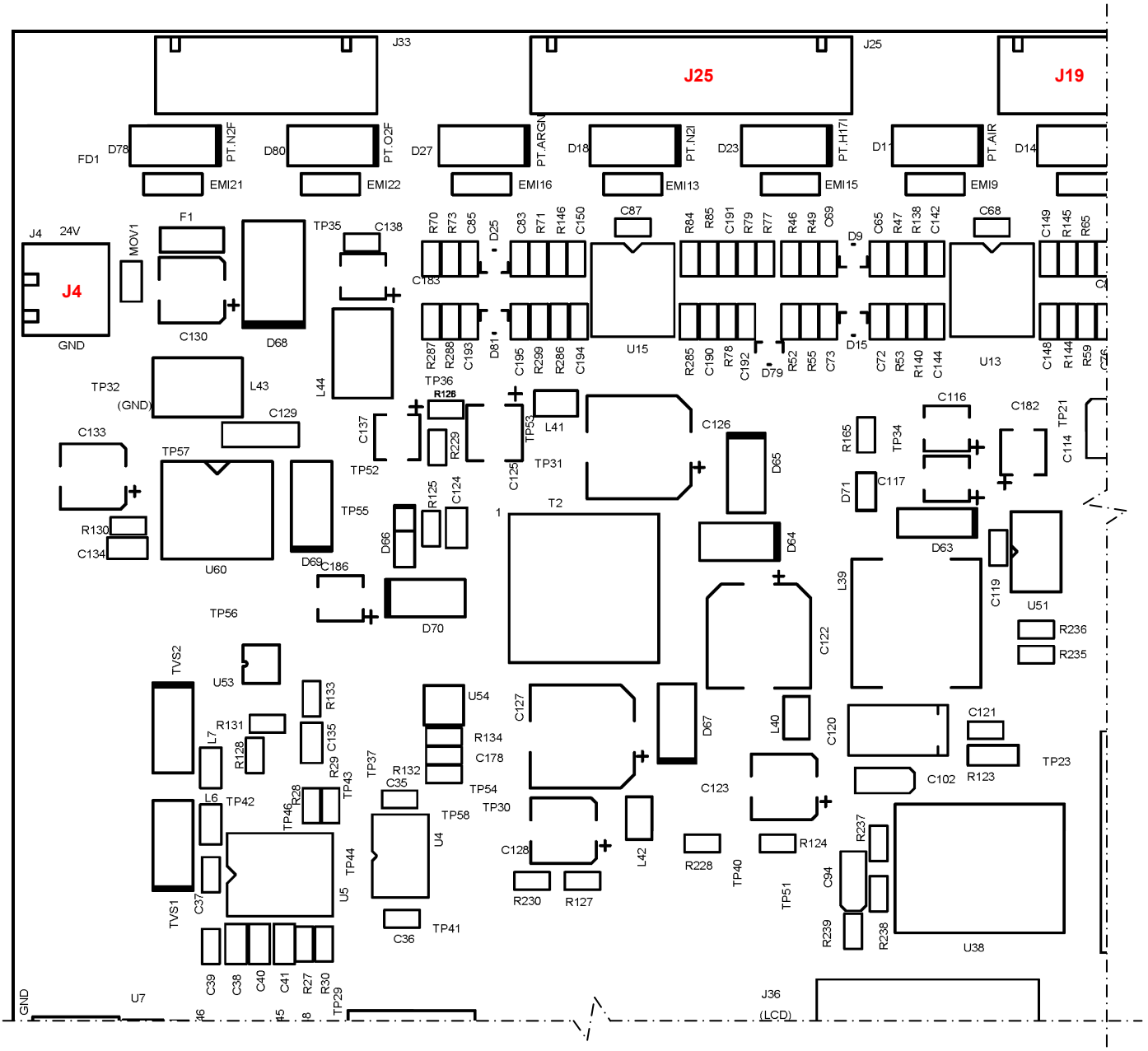
Gas Supply, Microprocessor DSP (BK300301) – Quadrant 1



PCB Quadrant Map



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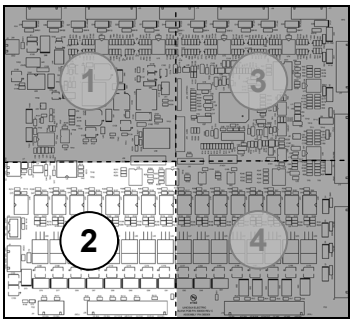
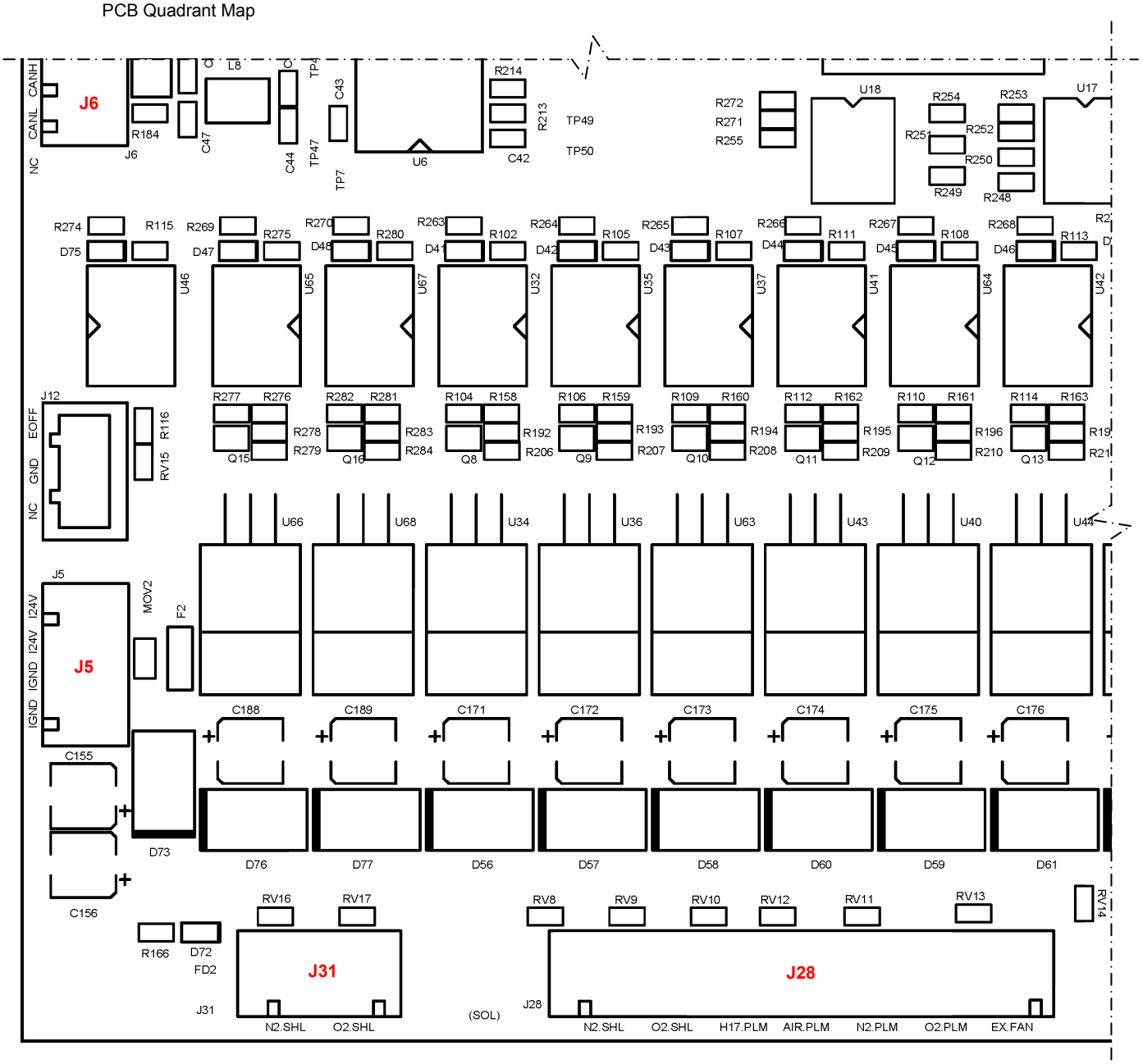
Gas Supply, Microprocessor DSP (BK300301) – Quadrant 2



PCB Quadrant Map



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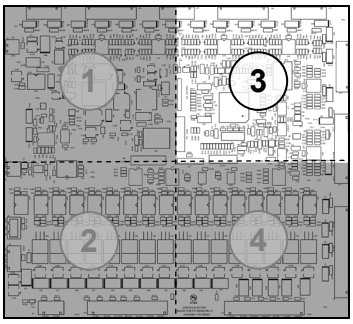
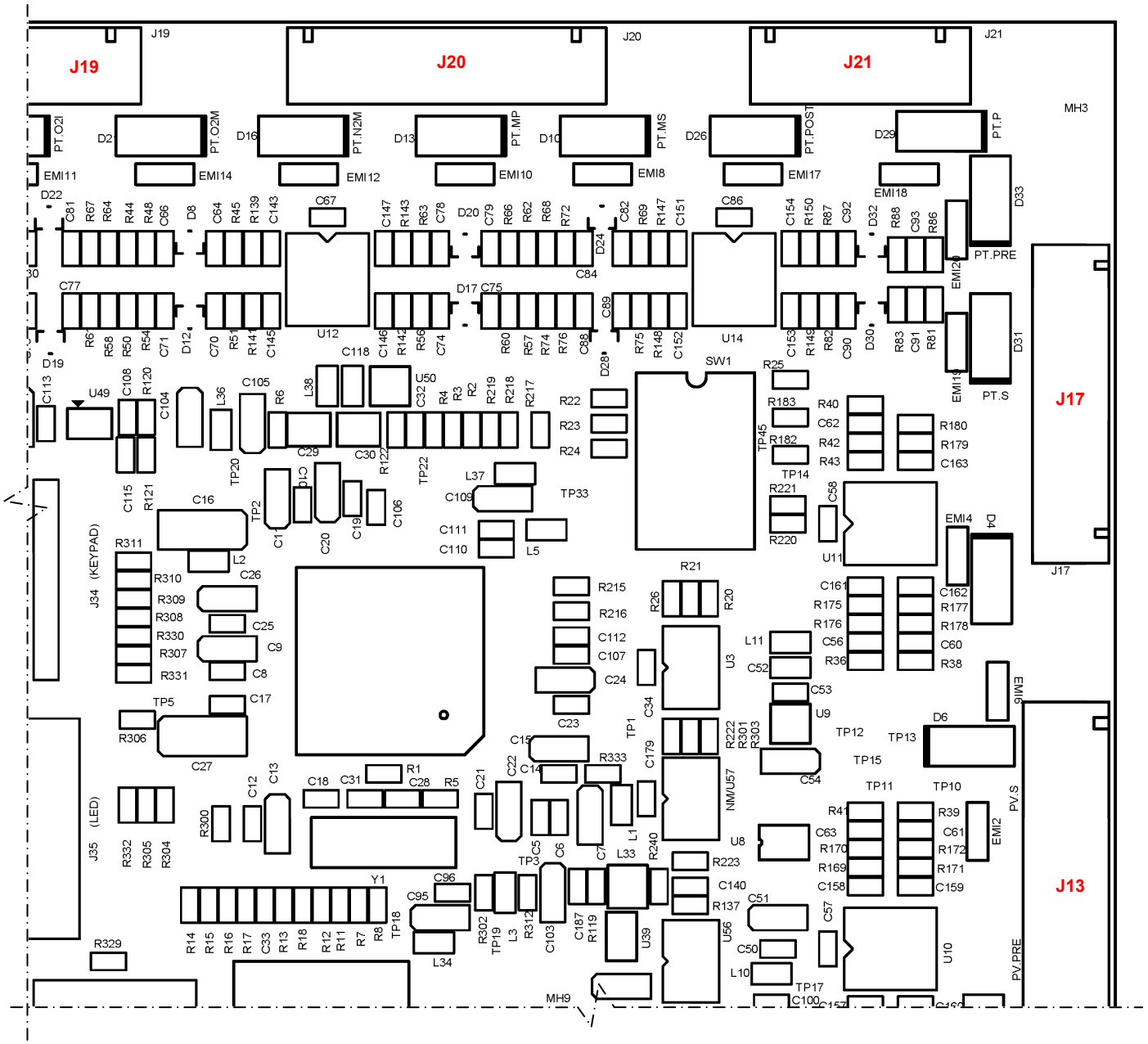
Gas Supply, Microprocessor DSP (BK300301) – Quadrant 3



PCB Quadrant Map



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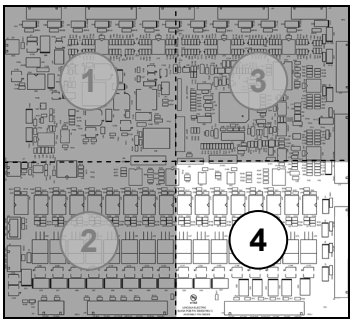
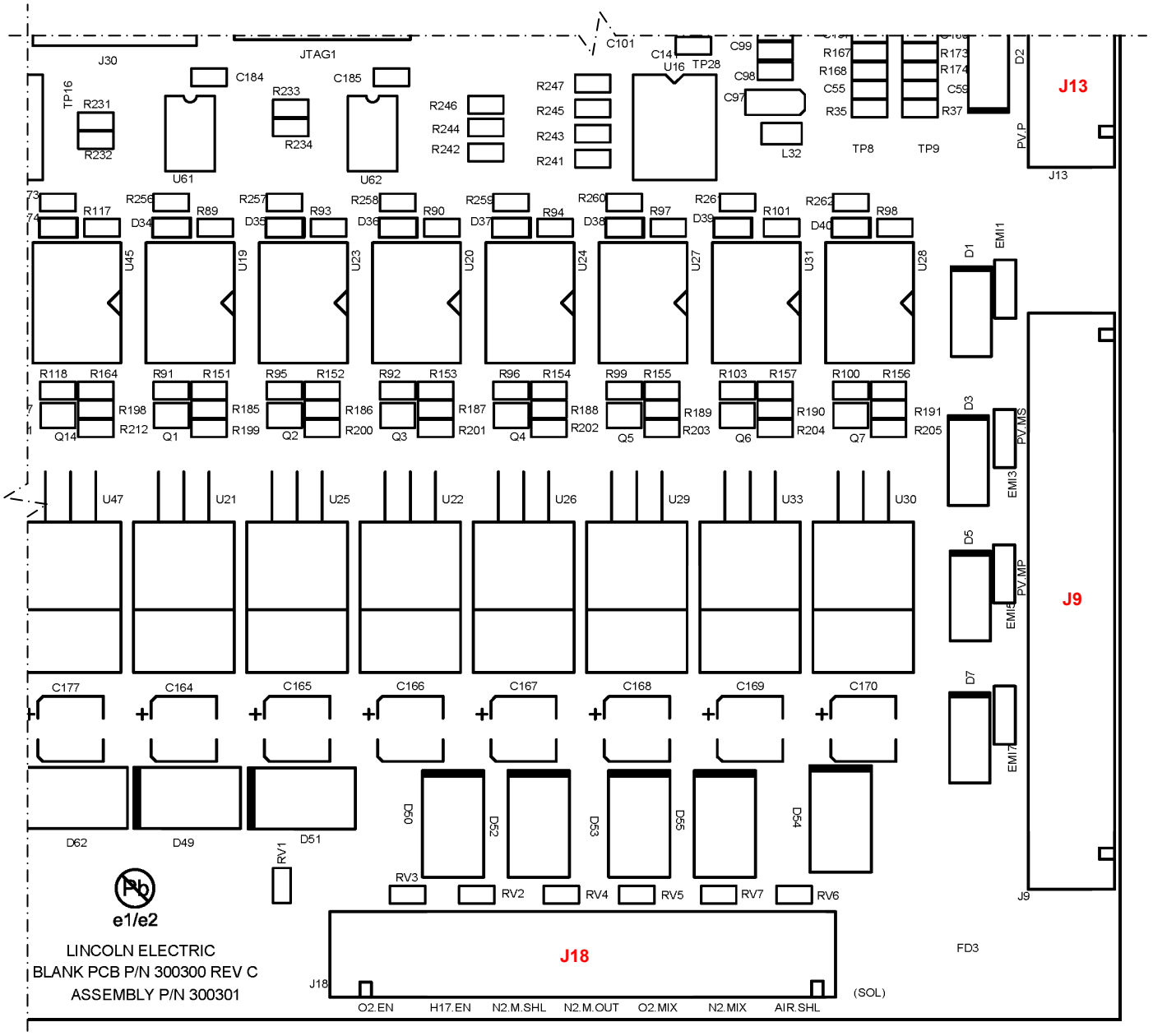
Gas Supply, Microprocessor DSP (BK300301) – Quadrant 4



PCB Quadrant Map



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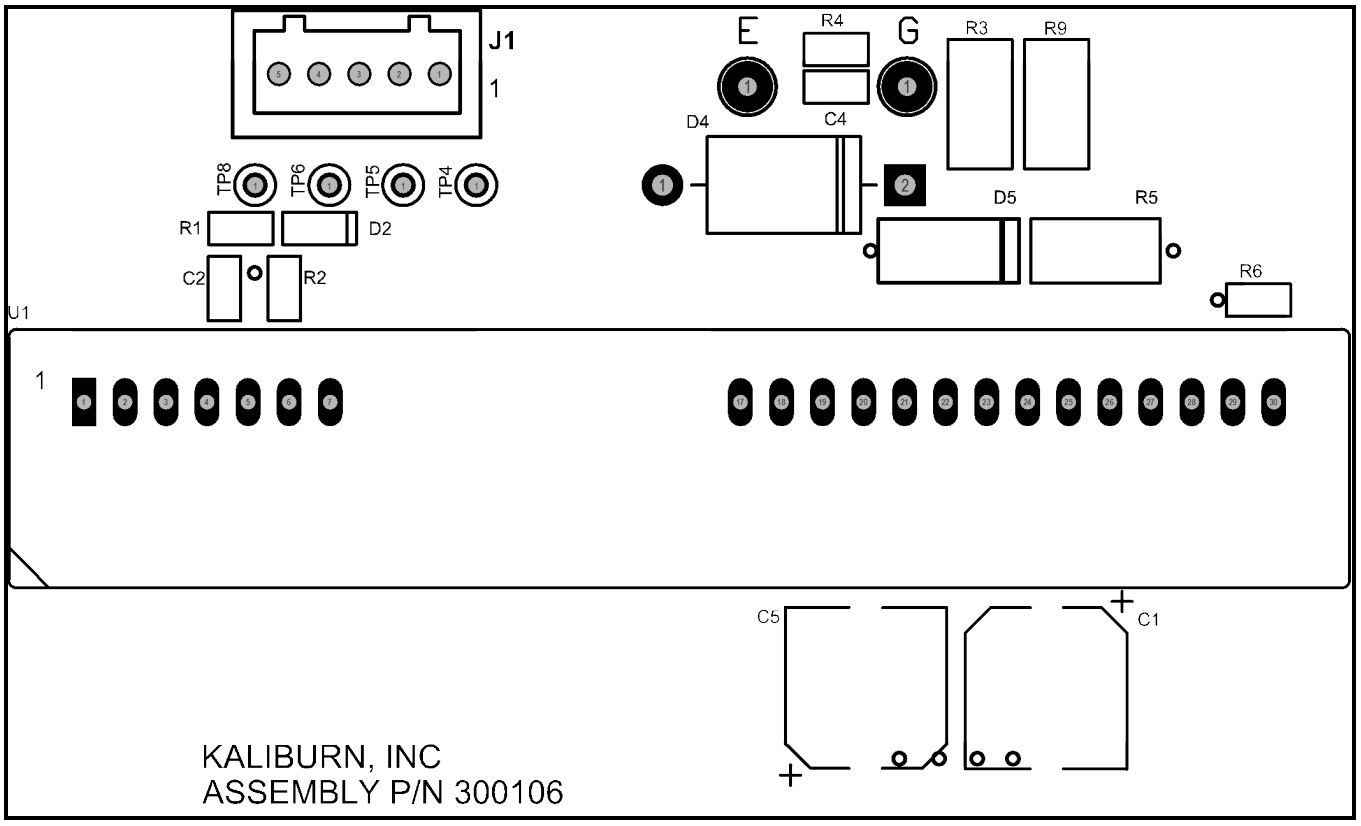
Chopper, Gate Driver (BK300106)



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Section 8: Internal Inova Console Option

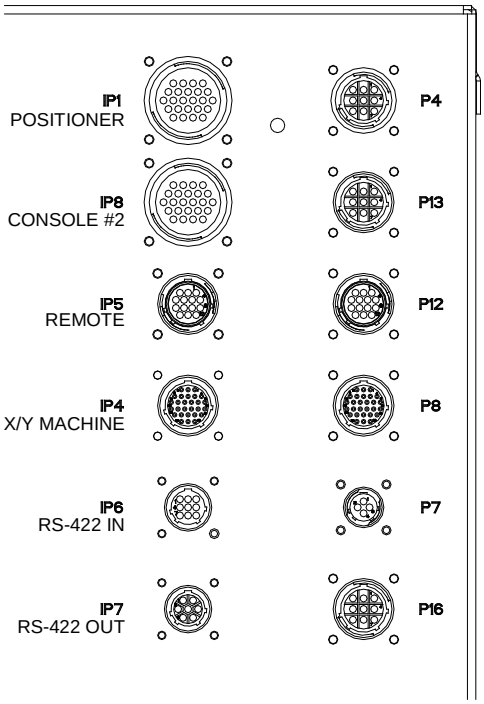
Overview

This optional Inova system is designed to provide arc voltage control to **any** plasma cutting system, however, combining it with the Spirit II provides the added convenience of having Inova console built directly into the plasma power supply.

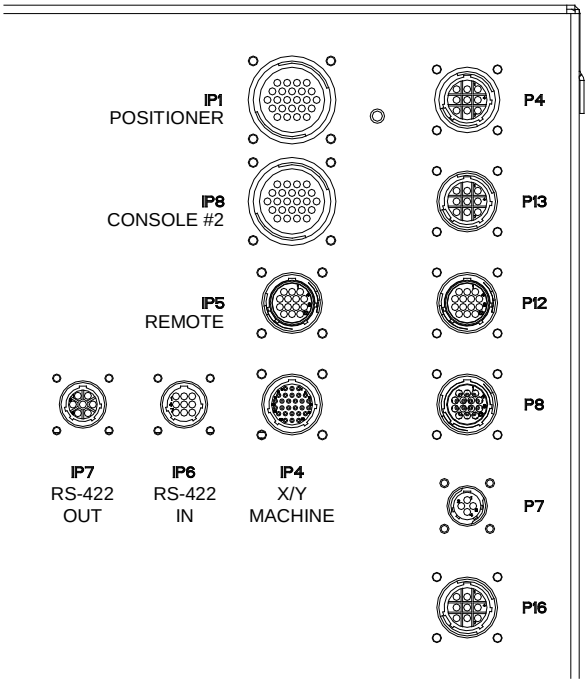
This section only covers topics unique to the Spirit II system with the internally installed Inova console. See the standard Inova manual for all other Inova information.

Plug Identification

Connections for the internal Inova console option are distinguished from other connections on the back of the power supply by the addition of the letter "I" before the plug number. The function of each plug (e.g., IP1) is the same as the corresponding plug found on the external Inova console (e.g., P1).



Spirit II 150/275



Spirit II 400

Unique Interconnect Cables

Two unique interconnect cables are required for this option with the Spirit II system. The FII cable is used to connect the Spirit II internal Inova console (IP4) to the X/Y Machine (CNC controller). The JII cable is used to connect multiple Spirit II internal Inova consoles (IP8). See the parts list in Section 7 for more details on these cables.

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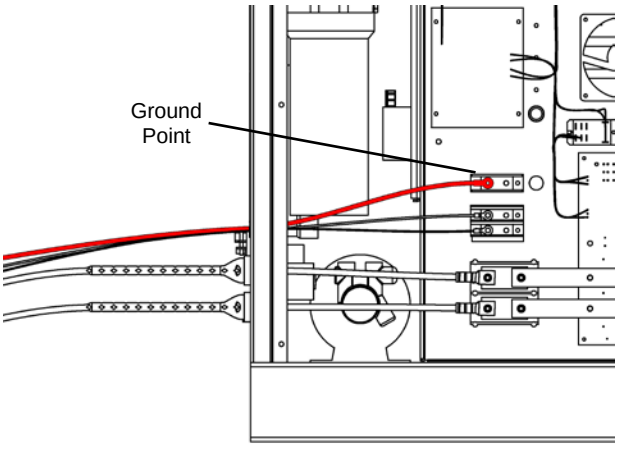
Grounding

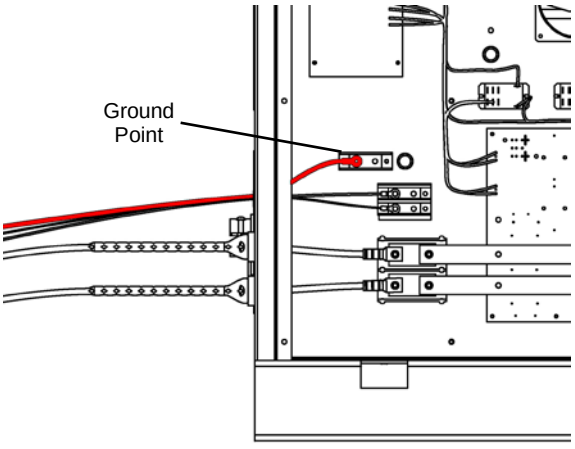
The internal Inova console must be connected to the same protective earth ground as the plasma power supply and in accordance with national or local codes. The figures below describe two methods. Use a minimum of #8AWG (10 mm^2) wire.

Note: the customer must supply the ground cable.

Direct to star ground:

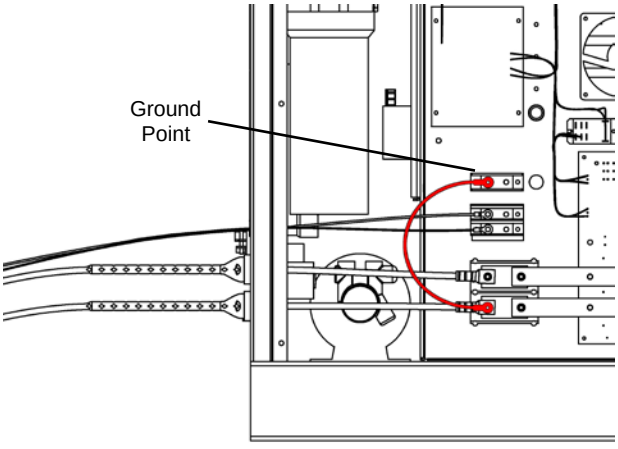


Spirit II 150/275

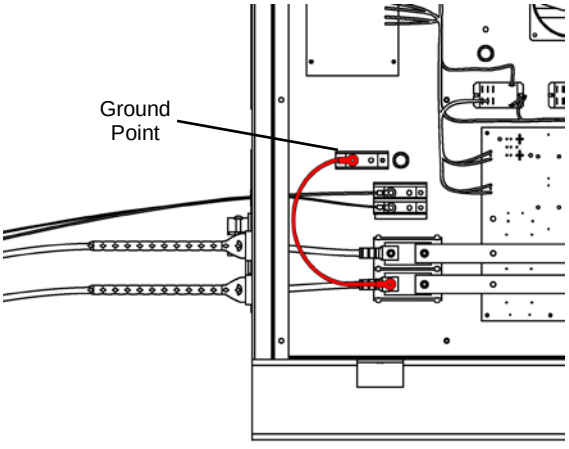


Spirit II 400

Jumper to the work ground lead:



Spirit II 150/275



Spirit II 400

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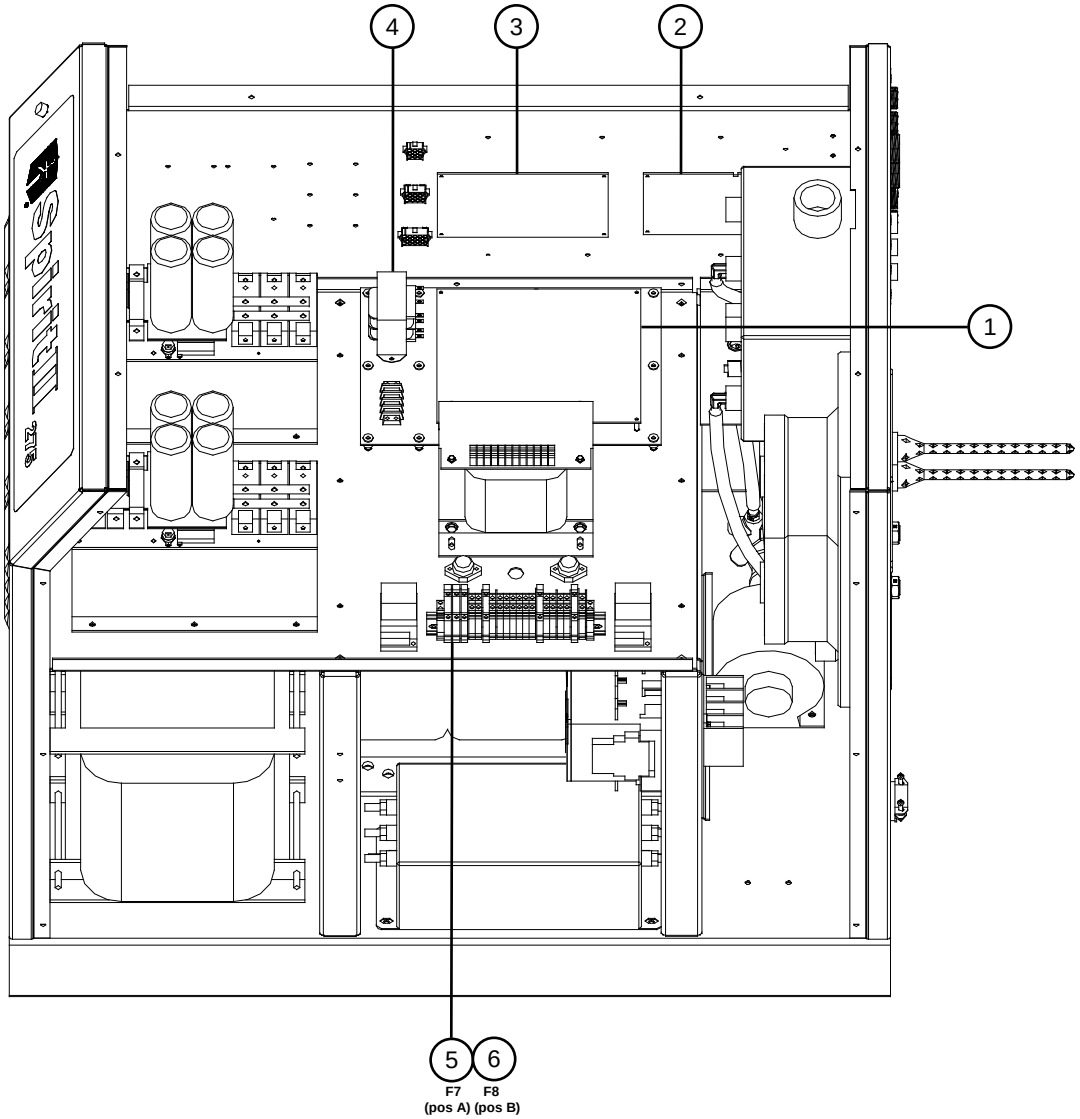
Parts List

Item	Part Number	Quantity	Description
1	BK110200	1	Printed Circuit Board (PCB), Microprocessor
2	BK110705	1	Printed Circuit Board (PCB), Power Distribution
3	BK110900	1	Printed Circuit Board (PCB), H-Bridge
4	BK706003	1	Transformer
5	BK709360	1	F7 Fuse, 6.3A
6	BK709370	1	F8 Fuse, 3A
7	BK301200	1	Printed Circuit Board (PCB), Voltage Divider
8	BK709276	1	Power Distribution Block,1 Pole

Location in Spirit II 150 & 275



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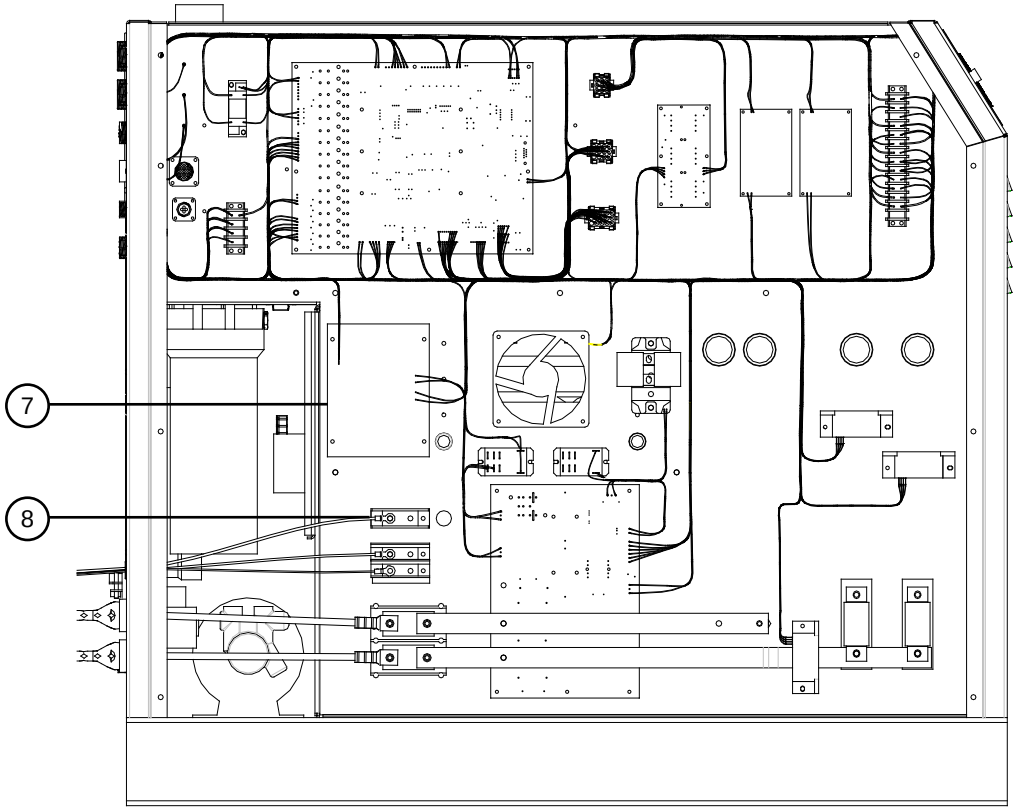
Location in Spirit II 150 & 275 - Continued



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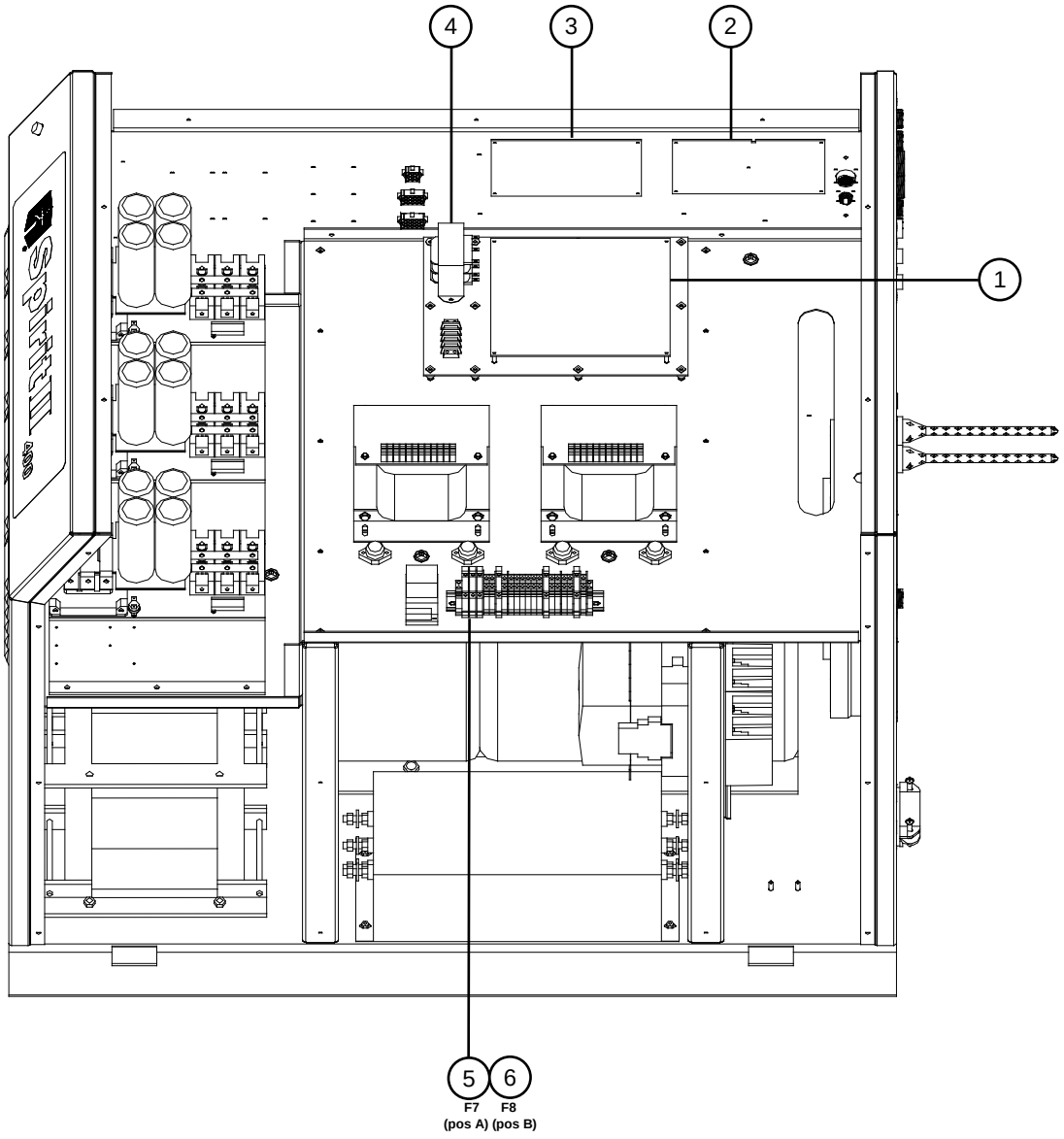
Location in Spirit II 400



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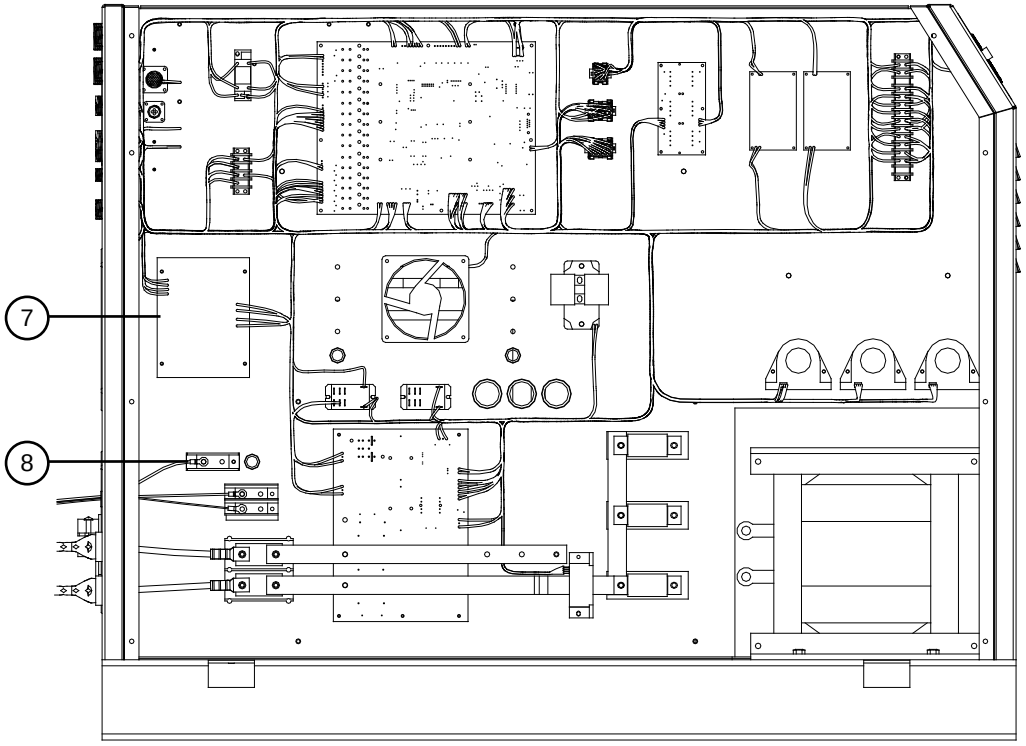
Location in Spirit II 400 - Continued



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Appendix A: Electromagnetic Compatibility (EMC)

Background

The 380V 50/60Hz and 415V 50/60Hz CE marked Spirit plasma cutting systems are manufactured to comply with the European standard EN 60974-10 (Electromagnetic compatibility (EMC) – Product standard for arc welding equipment). The system has been tested in accordance with CISPR 11, EMC classification – Group 2 ISM (Class A). The limits used in this standard are based on practical experience. However, the ability of plasma cutting equipment to work in a compatible manner with other radio and electronic systems is greatly influenced by the manner in which it is installed and used. For this reason, it is important that the plasma cutting equipment be installed and used in accordance with the information below if electromagnetic compatibility is to be achieved.

Plasma cutting equipment is primarily intended for use in an industrial environment. There may be potential difficulties in ensuring electromagnetic compatibility in other environments.

Installation and Use

The user is responsible for installing and using the plasma cutting equipment according to the manufacturer's instructions. If electromagnetic disturbances are detected then it shall be the responsibility of the user of the plasma cutting equipment to resolve the situation with the technical assistance of the manufacturer. In some cases this remedial action may be as simple as earthing the plasma cutting circuit, see Note. In other cases it could involve constructing an electromagnetic screen enclosing the plasma power source and the work, complete with associated input filters. In all cases, electromagnetic disturbances shall be reduced to the point where they are no longer troublesome.

Note: The plasma cutting circuit may or may not be earthed for safety reasons. Changing the earthing arrangements should only be authorized by a person who is competent to assess whether the changes will increase the risk of injury, e.g. by allowing parallel plasma cutting current return paths which may damage the earth circuits of other equipment. Further guidance is given in IEC 974-13 *Arc welding equipment – Installation and use.*

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Assessment of Area

Before installing plasma cutting equipment, the user shall make an assessment of potential electromagnetic problems in the surrounding area. The following shall be taken into account:

a) other supply cables, control cables, signaling and telephone cables; above, below and adjacent to the plasma cutting equipment;
b) radio and television transmitters and receivers;
c) computer and other control equipment;
d) safety critical equipment, e.g. guarding of industrial equipment;
e) the health of the people around, e.g. the use of pacemakers and hearing aids;
f) equipment used for calibration or measurement;
g) the immunity of other equipment in the environment; the user shall ensure that other equipment being used in the environment is compatible; this may require additional protection measures;
h) the time of day that plasma cutting or other activities are to be carried out.

The size of the surrounding area to be considered will depend on the structure of the building and other activities that are taking place. The surrounding area may extend beyond the boundaries of the premises.

Methods of Reducing Emissions

Mains Supply

Plasma cutting equipment should be connected to the mains supply according to the manufacturer's recommendations. If interference occurs, it may be necessary to take additional precautions such as filtering of the mains supply. Consideration should be given to shielding the supply cable of permanently installed plasma cutting equipment in metallic conduit or equivalent. Shielding should be electrically continuous throughout its length. The shielding should be connected to the plasma power source so that good electrical contact is maintained between the conduit and the plasma power source enclosure.

Maintenance of the Plasma Cutting Equipment

The plasma cutting equipment should be routinely maintained according to the manufacturer's recommendations. All access and service doors and covers should be closed and properly fastened when the plasma cutting equipment is in operation. The plasma cutting equipment should not be modified in any way except for those changes and adjustments covered in the manufacturer's instructions. In particular, the spark gaps of arc striking and stabilizing devices should be adjusted and maintained according to the manufacturer's recommendations.

Plasma Cutting Cables

The plasma cutting cables should be kept as short as possible and should be positioned close together, running at or close to the floor level.

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Equipotential Bonding
Bonding of all metallic components in the plasma cutting installation and adjacent to it should be considered. However, metallic components bonded to the workpiece will increase the risk that the operator could receive a shock by touching these metallic components and the electrode at the same time. The operator should be insulated from all such bonded metallic components.

Earthing of the Workpiece
Where the workpiece is not bonded to earth for electrical safety, nor connected to earth because of its size and position, e.g. ship's hull or building steelwork, a connection bonding the workpiece to earth may reduce emissions in some, but not all instances. Care should be taken to prevent the earthing of the workpiece increasing the risk of injury to users, or damage to other electrical equipment. Where necessary, the connection of the workpiece to earth should be made by a direct connection to the workpiece, but in some countries where direct connection is not permitted, the bonding should be achieved by suitable capacitance, selected according to national regulations.

Screening and Shielding
Selective screening and shielding of other cables and equipment in the surrounding area may alleviate problems of interference. Screening of the entire welding installation may be considered for special applications.

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